Flight 2000

Path to Free Flight

Initial Program Plan

July 16, 1997

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

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Dear Reader:

This Flight 2000 Initial Program Plan is FAA and industry's roadmap to provide operational improvements on the path to Free Flight, beginning in the year 2000.

The Plan is the culmination of a collaborative effort involving the FAA, NASA, DoD and industry (through the RTCA Free Flight Select Committee) to streamline the process of providing operational improvements to a wide spectrum of NAS users. Although the authors of this initial plan represent the key stakeholders in the evolution of air traffic control services, revisions to this plan can be anticipated as we jointly address the options and challenges of implementation.

The purpose of the Flight 2000 Initial Program Plan is to provide the reader with a strategic overview and details available at this stage in the planning process. The information includes:

- an overview of the driving forces and vision behind Flight 2000
- a discussion of the customers and partners
- a depiction of the benefits to be realized
- a delineation of the operational concepts that will deliver those benefits
- a presentation of the service architecture which will support the operational concepts
- details of the capabilities that enable implementation of the service architecture
- strategies to improve the certification of those technologies
- a schedule for implementing these strategies
- a cost estimate for Flight 2000 based upon the above information

This document is a high-level proposal to set forth the ground work for detailed planning in the next phase. It does not provide the implementation details that will be developed in the near future upon approval and funding of the Flight 2000 Program.

David B. Tuttle
Program Director, Flight 2000

Enclosure

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Introduction

In February 1997, the Federal Aviation Administration announced an initiative to demonstrate and validate an integrated set of capabilities to support Free Flight. In response to recommendations made by the White House Commission on Aviation Safety and Security, the plan is to accelerate National Airspace System (NAS) modernization.

This modernization will be demonstrated in Flight 2000, a real-world implementation of advanced communications, navigation, surveillance, and air traffic management capabilities to validate enhanced system benefits for all airspace users.

Flight 2000 is an aggressive initiative to deploy and evaluate selected planned air traffic management systems for the year 2005 NAS.[1] Flight 2000 integrates for the first time the requisite systems, procedures, and training necessary to provide improved NAS safety, security, productivity, capacity, and efficiency at affordable operations and maintenance costs. This integrated demonstration and validation will begin in September 2000.

Flight 2000 is an important precursor to Free Flight, a revolutionary air traffic management concept that greatly increases users' flexibility to plan and fly their preferred routes under instrument flight rules.[2]

The objectives of the Flight 2000 program are to demonstrate safety and efficiency benefits of new technology and improved procedures; evaluate communication, navigation, and surveillance (CNS) transition issues without a requirement for mandate; streamline avionics development, certification, and installation, thereby driving down costs; reduce risks for accelerated NAS modernization; develop controller and pilot tools for transition; and go beyond near-term procedural changes to make Free Flight a reality.

Many of the technologies that would foster free flight have been demonstrated in the laboratory or on a limited scale, but without conclusive establishment of true benefits and cost. These demonstrations have not been compelling to the point that most NAS users are willing to equip with the requisite systems. Flight 2000 provides the opportunity to take these activities to the next logical step, full operational demonstration and validation, where benefit/cost analyses can then occur. It not only sets the stage for the national deployment of the next generation air traffic management system, but also demonstrates new capabilities for better air traffic control with reduced controller workload.

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[1] Year 2005 is the new NAS deployment date mandated by the White House Commission on Aviation Safety and Security Report dated February 12, 1997.

[2] Free Flight changes the philosophy of FAA in aviation from that of air traffic control to air traffic management, providing new freedoms and increased safety for operators. Reduced restrictions and new capabilities will enable a pilot to choose their own routes whenever practical and file a flight plan that follows the most efficient and economical routes.

At the center of Flight 2000 is the integration of information via digital communications, navigation satellites, automatic dependent surveillance broadcasts, weather processors, cockpit displays, and air traffic control and flight planning tools for the safe planning and efficient execution of all phases of flight.

Flight 2000 operational capabilities, scheduled to begin in the year 2000 in Alaska, Hawaii, and selected Oakland Center oceanic airspace, will involve all classes of airspace users operating in all phases of flight operations and surface movement. Aircraft participating in Flight 2000 will be equipped with a new generation of advanced avionics.

Flight 2000 is a collaborative effort between industry and government. The Flight 2000 Steering Group, composed of representatives from FAA, NASA, and the U.S. aviation industry, provides high level guidance. The RTCA Free Flight Select Committee provides industry recommendations on candidate Flight 2000 operational improvements leading to free flight. A Flight 2000 Coordination Team has been formed to ensure commitment and participation from the many functional organizations.

Flight 2000 will provide an end-to-end integrated demonstration in which it is anticipated that all participating users will realize benefits. Any improvements that result will be applied to the rest of the NAS

Flight 2000 Initial Program Plan

The purpose of this initial Flight 2000 Initial Program Plan is to define the initiative at a high level, support the development of budget estimates, and establish a framework for more detailed planning, engineering, and scheduling activities necessary for the program to proceed. Substantial lower level planning including transition to the rest of the NAS is being initiated to provide additional detail needed to support Flight 2000 implementation.

The Flight 2000 Initial Program Plan encompasses a subset of capabilities from the RTCA Task Force 3 report and FAA operational concept for 2005. Those capabilities will reflect user priorities, be feasible for implementation by the year 2000, and add value as an integrated operational demonstration.

Flight 2000 Assumptions

To demonstrate and validate the capabilities of Flight 2000 integration, a number of assumptions were made. These include the fundamental assumptions that implementation planning is a joint government/industry activity and that certain infrastructure must be in place to support this initiative. Aircraft equipage is assumed to be voluntary and this will result in mixed equipage.

Flight 2000 Operational Environment

Hawaii and Alaska were selected as evaluation sites because of their unique features. They offer a controlled environment with a limited fleet allowing full-scale evaluation safely and quickly. In addition Alaska has a wide range of weather conditions and rugged terrain to help evaluate the safety benefits of improved weather information, on-board terrain databases, global positioning system navigation equipment, and other safety information in the cockpit.

Air traffic operations in both Hawaii and Alaska involve all classes of users and all categories of airspace. Because of their geographic isolation, each contains a relatively fixed quantity of aircraft that operate almost exclusively in these areas. Fleet sizes in each location are small enough to allow equipage of a majority of aircraft with new technologies, thus providing a scaleable evaluation in the very near term without major expenditures for aircraft avionics and ground equipment.

Flight 2000 Approach

FAA will upgrade the current ground infrastructure to provide necessary communications, navigation, and surveillance capabilities. Pilot training for use of newly installed hardware and new air traffic control procedures will be developed. The target is to equip diverse groups of operators: air transport operators including commuters, non-scheduled air taxis, general aviation -- from the basic instrument pilot to business jet operators -- military and public use. This equipage will allow a large percentage of the aircraft fleet to have the needed avionics in a short period of time, permitting a full assessment of the new capabilities. Certification of air traffic, navigation, and communications systems, as well as operational acceptance by FAA and industry users, is a prime focus of the demonstration.

Once the basic Flight 2000 capabilities are in place, progressive procedural improvements will be implemented in coordination with the user community. In addition, limited operational test bed activities will be conducted on promising capabilities as they mature.

Flight 2000 Operations Concepts and Improvements

The operations concept for Flight 2000 is a subset of the concepts in the recent document entitled *A Concept of Operations for the National Airspace System in 2005, dated June 27, 1997.* Flight 2000 will validate key operations concepts and improvements for the future NAS, and investigate related integration issues in an operational environment, and address the following key questions:

1. *What are the operational and technical implications of capitalizing on improved surveillance information (via ADS-B and CDTI) and the associated changes in procedures, roles, and responsibilities of pilots and controllers?*

2. *How does the widespread utilization of satellite navigation affect operations and safety?*

3. *Can controller/pilot datalink function effectively, efficiently, and safely, in an operational environment, and what functions and technology should a data link system be based on?*

4. *What avionics technologies and capabilities can be added to the cockpit that enhance utility at and affordable cost that encourages equipage?*

5. *What is the appropriate CNS architecture for the NAS that considers the full spectrum of digital communications needs?*

Equipage

Aircraft will be equipped with avionics enabling ADS-B; GPS navigation and approach guidance; and a multifunction display, processor, and data link supporting communications with ground facilities and display of flight information such as weather, terrain, and traffic. Specific areas of Alaska and Hawaii will have the corresponding ground infrastructure installed to support these capabilities.

An additional benefit of developing the new avionics required for Flight 2000 is the accelerated certification process and reduced cost for new avionics that may result, addressing the Task Force 3 near-term recommendation 12.[3]

Aircraft equipped with avionics enabling FANS capabilities and ADS-B will be able to participate in Flight 2000 in the Oakland Center oceanic airspace. Key capabilities that will be available are ADS-A, ADS-B (air-air), and CPDLC. The ground infrastructure for Oakland's Oceanic Automation System will support ADS-A and CPDLC prior to Flight 2000, and decision support systems for procedural separation will be installed for Flight 2000. Ground automation to support CPDLC in Oakland's domestic airspace will also be installed.

Three Parallel Tiers of Flight 2000

Services are divided into three parallel tiers. Tier I operational services would commence September 30, 2000 with the exception of some GPS approaches, which will be commissioned earlier, and will provide an early evaluation using a limited number of aircraft.

Prior to Tier I operational services, equipment will be installed, communications tested, and services readied for use. Human factors issues relating to presentation of information and avionics performance will be resolved, and avionics certified. Avionics will be

[3] RTCA Recommendation: Streamline the FAA certification process to reduce time and costs for approval and fielding of new and emerging technologies.

installed in the winter and spring of 1999-2000. Limited demonstrations will be conducted, leading to wider service availability starting September 30, 2000. Tier II operational services will be added as evaluations are completed.

Tier III evaluation activities will be unique test bed cases, using limited sets of avionics or ground systems to test and prove capabilities.

Cost

Flight 2000 will be funded from the R,E&D account as an addition to the existing program. Flight 2000 will require $398 M over a five-year period from FY-98 through FY-02. The majority of funding is required in the first three years; FY-98 $131 M, FY-99 $151 M, and FY-00 $77 M.

Conclusion

The results of the Flight 2000 concept validation and integration activities will accelerate the development of operational improvements to the NAS and support Free Flight Action Plan initiatives. Validated operational improvements will migrate from Flight 2000 locations to the rest of the NAS. From Alaskan bush planes and Hawaiian tourist aircraft to the most sophisticated airlines traversing the vast Pacific tracks, Flight 2000 will show the way to the next level of safe, modern, efficient, and globally harmonized aviation system well into the next millennium.

1.0 Flight 2000 Overview

1.1 The Purpose of Flight 2000

Flight 2000 is an innovative demonstration and validation of user defined improvements for the National Airspace System (NAS). It integrates the requisite systems, procedures and training necessary to provide improved NAS safety, security, productivity, capacity, and efficiency at affordable operations and maintenance (O&M) costs. This integrated demonstration and validation will accelerate NAS modernization so that the Federal Aviation Administration (FAA) will be better prepared to meet the air traffic demands projected for the next twenty years. This demonstration and validation will last two years beginning in September 2000. Besides the system deployment, it will refine air traffic control and flight procedures before national implementation, and clearly demonstrate the safety and cost benefits of the new systems and procedures to the NAS users. Its success will minimize the cost and risk in deploying new systems and procedures nationally by 2005, the new NAS deployment date mandated by the White House Commission on Aviation Safety and Security. By accelerating the date of modernization and the time for avionics equipage, the length of time when two parallel systems must be operated is reduced, with significant cost savings. Even more important, Flight 2000 represents the path to full Free Flight, the aviation community vision that allows aircraft operators to select their own path and speed in real time, under instrument flight rules.[1]

To meet this challenge, Flight 2000 employs new system acquisition and certification paradigms that exploit the early deployment and integration of rapidly-evolving technical capabilities into advanced ground-based systems as well as affordable, robust avionics. The envisioned infrastructure provides the key functions demanded by the NAS users. These functions include:

- Global Positioning System-based en route navigation, and Category I/II/III approaches and landings, i.e., WAAS/LAAS
- Automatic Dependent Surveillance-Broadcast (ADS-B)
- Controller-Pilot Data Link Communications (CPDLC)
- Flight Information Services, including FAA-provided weather information for the cockpit
- Cockpit display of terrain and/or traffic information for pilot situational awareness
- Decision Support Systems, including improved oceanic conflict probe

Flight 2000 is an aggressive initiative to deploy and operationally evaluate selected air traffic management systems planned for the modernized 2005 NAS. It focuses the various FAA modernization efforts to ensure that they provide the intended capabilities when integrated into the NAS. Flight 2000 integrates proposed modernization programs into a limited capability through which improved air traffic management can be achieved. System checkout and performance refinement can be performed without affecting the entire NAS and its users. It further deploys many of the enabling system capabilities for Free Flight. It integrates the improved

[1] Report of the *RTCA Board of Directors' Select Committee on Free Flight*, RTCA, Inc., Washington, DC, January 18, 1997.

communications, navigation, surveillance and air traffic management capabilities currently being developed for the 2005 NAS. Flight 2000 will be an operational demonstration and validation of *real* components by *real* operators and users. This real-world operational demonstration will permit a thorough evaluation prior to the decision to implement throughout the NAS. After a successful demonstration and validation, the system will remain in place to be the cornerstone of the 2005 NAS.

Flight 2000 is key to NAS modernization. Nothing else brings together the people, procedures and capabilities to cost effectively validate the modern NAS before its full national deployment.

1.2 Flight 2000 Driving Forces

The August 1993 report to the President by the National Commission to Ensure a Strong Competitive Airline Industry stated that "the outmoded air traffic control system is costing airlines and consumers billions of dollars each year in delays, and it badly needs to be modernized." Declining Federal budgets and unclear alternate FAA revenue sources have complicated this action. The maintenance of the NAS is consuming more and more of the FAA budget. Furthermore, too few dollars are being spent on system enhancements to meet future demands.

The situation is further exacerbated by the need for NAS users, such as the major and regional airlines, cargo carriers, helicopter cargo and tour operators, general aviation pilots, and the military to acquire new, or modified, avionics equipment at their own expense to complete the modernization.

It is clear today that affordability is the keystone upon which NAS modernization will be built. Balancing enhanced NAS safety, productivity and efficiency with affordability is the challenge for FAA and its aviation partners.

The White House Commission on Aviation Safety and Security was tasked to "*develop and recommend to the President a strategy designed to improve aviation safety and security, both domestically and internationally.*" A specific set of recommended actions resulted from the Commission's deliberations and were presented to the President for consideration and implementation on February 12, 1997. Among other things the commission recommended that NAS modernization be accelerated. Year 2005 is the new deployment date mandated by the Commission.

1.3 Flight 2000 Vision

The purpose of Flight 2000 is to evaluate modernized procedures and equipment in a controlled and realistic operational environment. Air traffic operations in Hawaii and Alaska involve all classes of users and all categories of airspace, making them ideal locations for this demonstration and validation. Because of their geographic isolation, each contains a relatively fixed quantity of aircraft that operate almost exclusively in these areas. Fleet sizes in each location are small enough to allow equipage of a majority of aircraft with new technologies, thus providing a scaleable evaluation in the very near term. These regions provide unique blends of domestic and

international procedures, equipment and processes. They encompass peak demand traffic areas with full surveillance and communications coverage, as well as areas in which such coverage is limited. Hawaii is an international destination that offers a unique opportunity to demonstrate U.S. capabilities for the rapidly growing aviation markets in Asia and elsewhere. Alaska experiences some unique challenges due to inclement weather near mountainous terrain, lack of widespread radar coverage, and numerous single-engine aircraft operations in remote areas. These factors account for an accident rate from weather-related factors and controlled flight into terrain (CFIT) that is nearly four times the rate in the contiguous 48 states. Improved operating procedures coupled with new capabilities such as cockpit display of weather, terrain, and nearby aircraft should cause a marked increase in safety within a very short time.

Operational improvements for the oceanic flight domain between Hawaii and the U.S. West Coast will be evaluated at Oakland Center. Operational evaluation of surface, departure/arrival and en route improvements will take place in Hawaii and Alaska. Details of the air traffic control systems in Alaska, Hawaii and Oakland are included in Section 3.

The FAA will upgrade the current ground infrastructure to provide the necessary communications, navigation, and surveillance capabilities. Pilot training for use of newly installed hardware and new air traffic control procedures will be developed by the FAA. The target is to equip diverse groups of operators: air transport operators including commuters, non-scheduled air taxis, general aviation -- from the basic instrument pilot to business jet operators -- military, and public use. This equipage will allow a large percentage of the aircraft fleet to have the needed avionics in a short period of time, permitting a full-faceted assessment of the new capabilities. All equipage for Flight 2000 will be voluntary, and accommodated through agreements with the aircraft operators. This approach is consistent with the precept of free flight, that the equipage will be voluntary. Certification of air traffic, navigation, and communication systems, as well as operational acceptance by FAA and industry, is a prime focus of the demonstration.

Flight 2000 will validate the capabilities of new equipment, systems, and procedures to increase flight safety, while decreasing the cost of the communications, navigation, and surveillance infrastructure. Once the basic Flight 2000 capabilities are in place, progressive procedural improvements will be implemented in coordination with the user community. In addition, limited operational test bed activities will be conducted on promising capabilities as they mature.

The White House Commission on Aviation Safety and Security also called for the "FAA to explore innovative means to accelerate the installation of advanced avionics in general aviation aircraft." This objective is incorporated into Flight 2000 by procuring and installing advanced avionics in all classes of aircraft, including general aviation. Many of the components and subsystems for advanced avionics can be found in products that have strong commercial markets. This economy of scale aspect will further lower the price of future avionics.

Many of the technologies that would foster Free Flight have been demonstrated in the laboratory or on a limited scale, but without conclusive establishment of true cost benefit. These demonstrations have not been compelling to the point that most NAS users are willing to equip with the requisite systems. Flight 2000 provides the opportunity to take these activities to the

next logical step, full operational demonstration and validation, where cost benefit quantification can occur. It not only will set the stage for the national deployment of the next generation air traffic management system, but will affirm U.S. leadership in aviation by demonstrating new capabilities for better air traffic control with reduced controller workload. Flight 2000 is essential to Government and industry efforts to evaluate the challenges of changing future operational concepts and air traffic procedures for the modernized NAS. The FAA cost for ensuring these critical benefits is estimated to be $398,645,000. Initial funding in the amount of $131,000,000 is required in FY1998 if Flight 2000 is to meet its goal of an operational capability in 2000.

1.4 Flight 2000 Assumptions

Flight 2000 is the integration activity that will provide a cohesive and functional transition strategy for the modernization of the NAS by the year 2005. Integration of systems prior to full NAS deployment will help to address a number of issues and assist in developing a cost effective transition plan. In order to demonstrate and validate the concepts and capabilities required of the Flight 2000 integration, a number of assumptions were made in the areas of system infrastructure, procedures, training, certification surveillance, navigation and communications. An example of one such assumption is that human factors research, procedures development, training and program development will be concurrent activities.

These and the other assumptions are based on the principles set forth by RTCA Task Force 3 and rely on industry and FAA programs to continue to implement products and capabilities throughout the NAS on which a strong framework for Free Flight and modernization can be built.

The major assumptions for Flight 2000 are:

- Implementation planning is a joint Government/Industry activity. Flight 2000 is consistent with the overall Free Flight Action Plan implementation priorities developed jointly by users and government. In particular, the user community has indicated that continued implementation of near term free flight activities including national deployment of a conflict probe, installation of Center TRACON Automation System (CTAS) at selected major terminals, and collaborative decisionmaking (CDM) capabilities should take precedence over deployment of Flight 2000 capabilities. Each Flight 2000 capability implemented is directly linked to a Task Force 3 recommendation and is contained in the operational concept for NAS of 2005.

- Focus is on implementing operational improvements. The capabilities and operational improvements were selected and prioritized with the following criteria: 1) No system or capability currently planned for deployment prior to the year 2000 would be affected. Examples: CTAS will continue development and integration activities in DFW and other selected locations; URET will be implemented and tested in Indianapolis and Memphis ARTCC's and other adjacent facilities; collaborative decisionmaking (CDM) ground to ground will be in place between all major air traffic control facilities, ATCSCC, and aircraft operation centers (AOC). One exception to this may be a delivery schedule change to get necessary infrastructure in place to fully evaluate integration activities. 2) Technologies that

are not proven or currently available will be evaluated in the Flight 2000 test bed. 3) Where there are choices as to which technology should be used to deliver a capability, {e.g., controller/pilot data link communications (CPDLC) via future air navigation system (FANS) with a transition to an aeronautical telecommunications network (ATN) when available}, Flight 2000 will use the most mature technology that meets the operational need. Selection of an initial technology for Flight 2000 does not preclude the selection of a different technology prior to NAS wide deployment. An example of this is the use of the 1090 squitter for ADS-B as the initial test link to evaluate and approve operational services. The FAA will evaluate, with industry participation, all available ADS-B candidate technologies with respect to the desired operational capability, in the context of an overall CNS architecture, prior to the long-term selection of an ADS-B architecture.

- FAA/Industry infrastructure must be in place. Operational improvements in Flight 2000 are being developed in the context of overall NAS modernization. Future NAS infrastructure will include a global positioning system (GPS), wide area augmentation system (WAAS), local area augmentation system (LAAS), advanced avionics capability, host interface device (HID) NAS local area network (LAN), standard terminal automation replacement system (STARS) preplanned product improvements (P^3I) by 2001 and display system replacement (DSR). Also, a number of procedural changes such as 50/50 separation and reduced vertical separation minima (RVSM) in the oceanic environment will form the base for operational improvements during the validation period.

- Equipage is Voluntary. All aircraft equipage in Flight 2000 will be on a voluntary basis. Even more, capabilities being validated are ones that are expected to provide users incentives to equip consistent with the Free Flight objective of voluntary equipage.

- Equipage will be mixed. Capabilities being evaluated do not require total equipage to provide benefits. Mixed equipage will help identify the optimum transition path into the remaining NAS.

1.5. Flight 2000 Benefits

The following is a list of some of the benefits that will accrue with the implementation of Flight 2000 capabilities:

- **Increased airspace flexibility and accessibility through reduced separation minima**. By reducing separation minima, more aircraft will fly at their optimum altitude, speed and routing, resulting in lower cost for the operator.

- **Dynamic rerouting, dynamic management of route structure, flexible tracks, optimum altitude, step climb, cruise climb**. Accurate position information will ensure these procedures are approved.

- **Enhanced decision support systems to assist service providers in maintaining separation, assigning runways, and sequencing aircraft**. These improvements

are based upon accurate and timely positional information being provided to the controller, in some cases through radar coverage and other cases through ADS-B.

- **Increased pilot situational awareness**. GPS navigation coupled with improved cockpit information and displays will enable applications such as graphical weather display in the cockpit, display of nearby air traffic, rendering of nearby terrain, and transmission of flight information such as special use airspace (SUA), notices to airmen (NOTAMS), and significant weather advisories.

- **Reduce taxi delays in low visibility operations**. Because controllers will no longer have to rely strictly upon having visual sight of each aircraft for positive control, aircraft will be able to taxi to and from runways with fewer delays.

- **Improved access to weather and flight information**. Users will be able to tailor their requests to certain types of products including weather information. Data will be displayed using both text and graphics and be as close to real time as possible.

- **Additional departure routes, arrival routes, and precision approached based upon satellite navigation aids**. By using waypoints based upon GPS locations, new routings can be designed to get aircraft into or out of the airport area more quickly and safely.

- **Increased surveillance coverage**. The ability to increase surveillance coverage without adding more ground based radars depends on the aircraft's ability to accurately determine its location. This benefit will be a major factor in improving air operations in remote areas, such as northern Alaska.

- **Improved safety through more accurate and reliable surface detection capabilities and display of surface traffic in the tower and in the aircraft**. Safety will be enhanced as runway and taxiway incursions are reduced. Some operators believe the benefit will be economic as well when they can better manage their ground vehicles operating on airport surfaces.

- **Additional non-precision approaches**. WAAS will provide navigation accuracy giving non-precision instrument approach capability to many airports that currently have no instrument approaches. WAAS would also give some airports the capability to add CAT I precision approaches.

1.6 Flight 2000 Objectives

To focus the program's planning and implementation strategies, Flight 2000 objectives were developed early in the planning phase to ensure timely delivery of products and benefits.

The objectives are:

- Accelerated achievement of Free Flight safety increases and economic efficiencies in air traffic management and control operations
- Increased air traffic services to Hawaii and Alaska general aviation, air taxi, and regional carriers
- Increased air carrier operational efficiency in the Pacific Oceanic environment and associated CONUS transition airspace
- Increased air transportation system safety in the Hawaii and Alaska Airspace
- Reduced risk of transition to the rest of the NAS
- Reduced costs for avionics and ground-based systems due to design and operational use issues being resolved prior to full-scale production of the systems and equipment

To carry out these objectives, the magnitude and complexity of program work activity will be significant. During the planning of Flight 2000, FAA worked extensively across organizational lines and conducted a variety of inter-organizational system engineering efforts. We will continue to work in this manner during the execution of Flight 2000 to ensure its success. The model in Figure 1.6-1 captures the methodology we will continue to integrate our efforts effectively within the FAA and to achieve a successful partnership with the aviation industry.

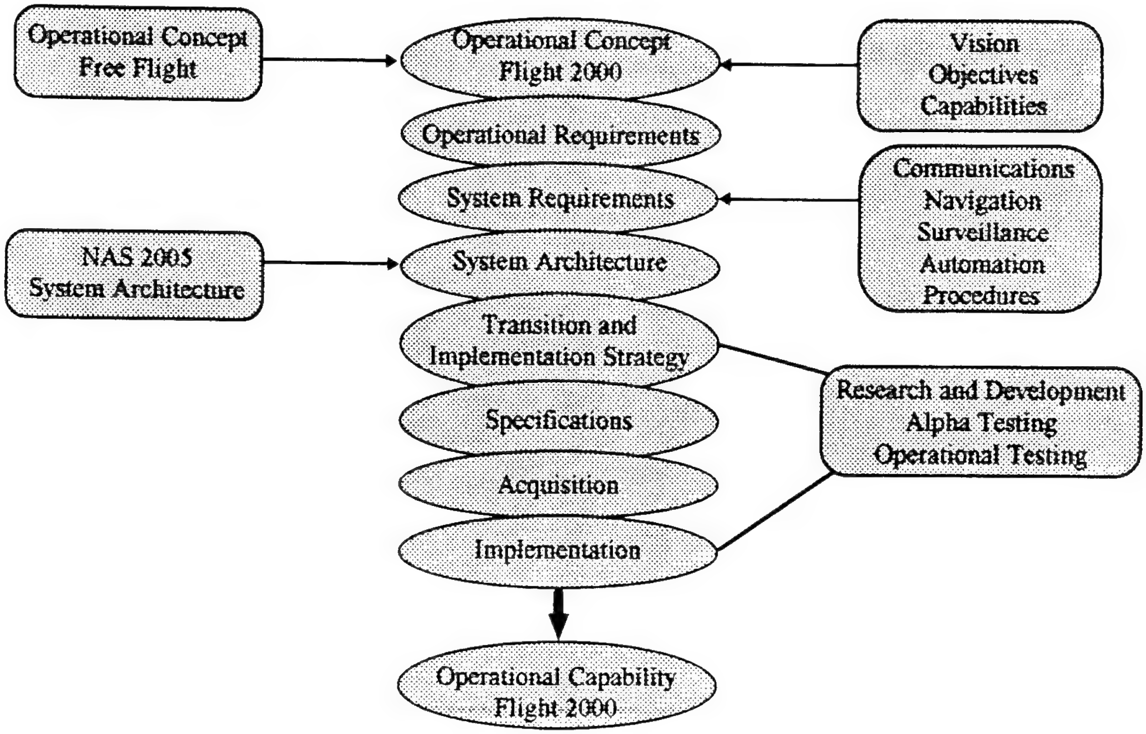


Figure 1.6-1 Roadmap for Flight 2000

1.6.1 Key Questions to be Addressed by Flight 2000

The Flight 2000 initiative will address a fundamental issue concerning aviation industry:

> **How can new operational procedures, enabled by introduction of new technology within the NAS, be introduced expeditiously and affordably?**

All of the activities within Flight 2000 address this fundamental issue. Activities within Flight 2000 addressing this include:

- The process for certification and operational approval needs to be streamlined, so that systems are viewed end-to-end, with appropriate levels of quality assurance that enhance overall system safety.

- Fielding of capabilities is increasingly a collaborative decision by users and air traffic service providers, such as was required for implementation of the FANS program. This project will provide more experience in collaborative decision making, along with process adjustments needed to allow decisions to be made and carried out.

- Expedited validation of operational modes will be required, with increasing emphasis on human factors and operational performance, rather than specific equipment or avionics configurations.

The experience and knowledge gained from addressing these issues in Flight 2000 will be applied to operations in the larger NAS, as the FAA and the aviation industry move towards modernization and Free Flight.

Five key changes in operations will be addressed in Flight 2000 related to the introduction of new technology, in the areas of surveillance, navigation, communications, and avionics, as outlined below.

1. ***What are the operational and technical implications of capitalizing on improved surveillance information (via ADS-B and CDTI) and the associated changes in procedures, roles and responsibilities of pilots and controllers?***

   To resolve this question, Flight 2000 must address issues related to procedure changes, human factors for controller displays, technical issues related to receiving ADS-B data in areas not covered by radars, using ADS-B data and radar data for tracking and display, and applicable separation standards. Key technical issues with respect to ADS-B include selection of a long-term link technology, failure modes, and the overall CNS architecture that includes ADS-B for both air-ground and air-air use as well as other digital communications, including flight information services, GPS augmentation, and pilot/controller communications.

   Activities will include the addition of surface, terminal, and en-route surveillance data to service providers, via a combination ADS-B and multilateration. Surface surveillance improvements will be implemented in Anchorage, Bethel, and Honolulu. LAAS will be installed at these airports to support needed surveillance accuracy requirements. In addition, ATC surveillance will be expanded in a number of non-radar sites across Alaska and Hawaii airspace. Flight 2000 will also implement a number of ADS-B aircraft-to-aircraft applications that make use of information available via a CDTI, in terminal and non-radar (primarily oceanic) airspace. To introduce these new operations, procedural, safety and human factors issues will be addressed. Technical issues related to display requirements, integration of ADS-B and other surveillance information, and the associated avionics upgrades will also be addressed.

2. ***How does the wide-spread utilization of satellite-based navigation affect operations and safety?***

   Flight 2000 will implement a number of GPS approaches, precision departures and arrivals, and GPS IFR/VFR routes across Hawaii and Alaska. LAAS will be added at a number of airports to support some higher-capability procedures not possible with GPS/WAAS alone. As part of Flight 2000, the significant benefits associated with the ability to define and fly "random routes" both within and outside of radar coverage will also be explored. With the wide-spread use of satellite-based navigation, overall integrity and availability issues need to be resolved, such as for the case of selecting alternate airports when satellite navigation does not support the needed landing capability for the primary destination airport. Flight 2000 will provide the data necessary to support

decisions on the extent to which ground-based navigation systems can be decommissioned.

3. ***Can controller-pilot datalink function effectively, efficiently, and safely in an operational environment, and what functions and technology should a datalink system be based on?***

To address issues related to digital communications between pilots and controllers, Flight 2000 activities will resolve issues related to procedure changes, human factors of cockpit crew and controller, technical implementation, and cost/benefit of using CPDLC as the main vehicle for ATC communications with aircraft.
As a vehicle for this, Flight 2000 will extend the applicability of CPDLC via FANS to oceanic/en route transition sectors within Oakland airspace, building on currently-equipped FANS aircraft. In addition, the Flight 2000 CPDLC system in Oakland will communicate with ATN avionics when they are operational.

4. ***What avionics technologies and capabilities can be added to the cockpit that enhance utility at an affordable cost that encourages equipage?***

Currently, avionics providing new capabilities are expensive and difficult to upgrade, reducing incentives for users to add avionics that add utility or improve overall operations. For example, a major impediment to improving pilot situational awareness is the cost and feasibility of providing increased information to pilots. Current voice communications are limited in both the amount, and extent of information that can be conveyed. Concerns to address include human factors related to the display of information, pilot workload in the context of the flight mission, and the cost of maintaining and updating data bases and other capabilities. Technical issues to address include the integration of new capabilities into current avionics configurations, upgrading of current capabilities, and certification. Flight 2000 will provide improved awareness of navigation, terrain, weather and flight information, and traffic through the development of an integrated low-cost avionics suite that includes onboard data bases. Improved weather and flight information will be provided via data link, moving map displays will use GPS position data, a traffic display will enhance safety using ADS-B and uplinked traffic information, and terrain data will be added to reduce the chance of CFIT.

5. ***What is the appropriate CNS architecture for the NAS that considers the full spectrum of digital communications needs?***

The Flight 2000 architecture will lay the groundwork for NAS modernization, as well as support the key operational objectives of Flight 2000. The CNS architecture for the NAS should accomodate user needs including GPS navigation and augmentation, ADS-B, Flight Information Services (including weather, NOTAMS, SUA, etc), and controller/pilot communications. The architecture needs to consider both broadcast and addressed digital communications, spectrum, and sharing of services over digital links, considering both dedicated and commercial communications options. The architecture selected for the

provision of services in Flight 2000 will provide vital experience and data in assessing overall NAS CNS architecture decisions.

1.7 Flight 2000 Customers and Partners

The planning and execution of this demonstration and validation is a joint Government/industry program. Industry input to this plan has been coordinated through the RTCA Select Committee for Implementation of Free Flight and will continue to be solicited as the planning process continues. Flight 2000 is an opportunity for users, operators, and the aviation industry to collaborate on the development and deployment of operational capabilities that will alter the nature of aviation well into the 21st century.

Flight 2000 partners include:

RTCA, Inc.

RTCA Task Force 3 was created to develop an industry-wide consensus on the implementation of Free Flight concepts formulated by the RTCA Board of Directors' Select Committee on Free Flight. The Task Force 3 Final Report on Free Flight Implementation is a key document upon which Flight 2000 is based. The operations concepts and improvements set forth for Flight 2000 are linked to the recommendations of Task Force 3 and Free Flight Action Plan.

RTCA continues to participate in the planning of Flight 2000 through their membership on the Flight 2000 Steering Group. RTCA's continued support will be a necessary element in the success of Flight 2000.

Department of Defense

Because of their shared interests in aviation and space related activities, the FAA and the Department of Defense (DoD) have a long standing and close relationship. More than 40 FAA R&D partnership agreements are currently in place with DoD and its services. Many of these agreements pertain to technologies that are pertinent to Flight 2000 and the future NAS.

Flight 2000 will use DoD aircraft in the operational evaluation of new capabilities and procedures. The FAA will act as an agent for DoD in the procurement avionics for selected aircraft based in Hawaii and Alaska. These aircraft will be among the first to participate in the early phases of the controlled implementation of new capabilities and procedures. FAA and DoD will also work closely to improve access to military Special Use Airspace (SUA).

NASA

The National Aeronautics and Space Administration (NASA) will continue to play a role in support for development of advanced aviation concepts for Flight 2000. From its initial membership on the RTCA Board of Directors Select Committee on Free Flight through its current participation on the Flight 2000 Steering Group, NASA plays an important role in defining the future of the National Airspace System.

There are three NASA programs that are particularly beneficial to support the goals of Flight 2000: the Short Haul General Aviation element of the Advanced Subsonic Technology program, the Aviation Capacity research program and the Aviation Safety Research program.

Particularly crucial will be the established and ongoing efforts of the Advanced General Aviation Technology Experiments (AGATE) program, a joint Government and industry activity created to revitalize general aviation through development and coordination of standards for advanced technologies. The AGATE consortium consists of 70 industry members from 36 states and is coordinating improvements in the entire general aviation spectrum from propulsion and integrated flight systems through NAS infrastructure support and training systems.

Specific applications of AGATE components relevant to Flight 2000 are:

- Data link architecture including data link messages,
- Integrated cockpit information systems (ICIS) for display of weather, moving maps, traffic information, terrain and system status, and
- Training products for ICIS, icing conditions and free flight operating procedures.

Through the negotiation and approval of standards between industry and Government, AGATE will insure that general aviation communications, navigation and surveillance systems will be compatible with all data link transmission modes and keying schemes. Its members have committed to continuing their 50% funding of this important endeavor. NASA is an important Government partner in assuring this joint venture with industry will bear fruit, not only for Flight 2000, but for the future of general aviation.

International Partners

Although the emphasis of Flight 2000 will be to enable transition of new technology and procedures to the continental U.S., the impact of these changes must be coordinated with the international community. To this end, ICAO will be invited to participate in an observer role during Flight 2000. ICAO will be the organization that will continue to harmonize the international implementation of the air traffic management paradigm of the future.

1.8 Free Flight Definition

Since many of the capabilities of Flight 2000 will enable the ultimate achievement of Free Flight, it is appropriate to define Free Flight here. The Free Flight concept is a joint initiative of the global aviation industry and the FAA. According to the *Final Report of the RTCA Task Force 3, Free Flight Implementation,* RTCA, Inc., Washington, D.C., October 26, 1995, Free Flight is defined as:

"...a safe and efficient flight operating capability under instrument flight rules (IFR) in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are only imposed to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through Special Use Airspace (SUA), and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move toward free flight.

This suggests that each user is granted *both* maximum flexibility *and* guaranteed safe separation. The goal is not only to "optimize" the system but to open the system for each user to "self-optimize". Self-optimization is the key to understanding the extent of free flight's reach as well as free flight's challenges. Free flight is not limited to airspace—its spatial constraints are chock-to-chock, but free flight reaches into a flight's pre-history by providing increased flexibility in flight planning."

2.0 Operations Concept

2.1 The Flight 2000 Operations Concept

2.1.1 Background

On April 20, 1995, the FAA Administrator asked RTCA to form a new task force, led by an appropriate representative from the civilian aviation community, to develop consensus regarding free flight implementation. The Task Force completed its work October 31, 1995, and produced a report, *The Final Report of RTCA Task Force 3: Free Flight Implementation* (RTCA, 1995), that offers a definition of Free Flight concepts, an evaluation of architecture and technology needs to support them, and a high-level incremental implementation plan. The report sets forth 46 recommendations for moving forward toward free flight in three timeframes: near-term, present through 1997; mid-term, 1998 through 2000; and far-term, 2001 and beyond. The report highlights the views of the aviation community and presents a challenge to system developers and implementers by describing a future NAS that permits the greatest flexibility for planning and conducting flights according to user-defined preferences. This challenge can only be met with improved operating efficiencies and increased levels of capacity and safety.

The dominant recommendation of Task Force 3 was to form a Free Flight Steering Committee to enhance the FAA/aviation community collaboration during the transition to free flight and to establish an agreed-to implementation strategy and milestones. In the Spring of 1996, a *Free Flight Action Plan* was developed that represented a joint commitment between the FAA and industry to those initiatives necessary to implement free flight. The *Free Flight Action Plan* builds on the work of Task Force 3 and identifies specific initiatives designed to either implement RTCA recommendations or further define free flight concepts to the next level of detail to aid in implementation.

2.1.2 Integration Issues

Progress is being made on some of the near and mid-term *Action Plan* initiatives and the aviation industry believes that these initiatives will provide benefits based on current development and implementation plans. No funds should be diverted from these priority initiatives, in fact, every effort should be made to fully fund them. However, there are some initiatives in the mid and far-term that would benefit from integration efforts.

- ADS-B
- Data Link
- Automation (ground and cockpit)

Integral to the above initiatives are the key issues of procedured development, human factors, and certification. Flight 2000 is an opportunity to accomplish these integration activities and

accelerate associated mid and far-term initiatives, without diverting resources from or delaying any of them.

2.1.3 Concepts to Validate

Flight 2000 is an initiative to demonstrate and validate an integrated set of technical and operational capabilities to support the implementation of free flight. The operations concept for Flight 2000 is a subset of the concepts in the recent FAA document *A Concept of Operations for the National Airspace System in 2005, dated June 27, 1997*. Flight 2000 will validate key operations concepts and improvements for the future NAS, and investigate related integration issues in an operational environment for four specific areas:

1. ***Improve surveillance coverage with Automatic Dependent Surveillance (addressed and broadcast) and Cockpit Display of Traffic Information (CDTI).***

Concept: Participating aircraft will be displayed on ATC traffic displays with positions derived from ADS-A reports, and ADS-B reports if appropriate, while outside radar coverage. When participating aircraft are within radar coverage, their displayed position will be based on a fusion of ADS and radar reports. The new surveillance information will allow separation requirements for participating aircraft to be reduced from current procedural separation standards while outside radar coverage in domestic airspace, providing increased granting of user preferred routes and altitudes. ADS-B will provide an increased situational awareness of other equipped aircraft on the airport surface as well as while airborne. Traffic will be displayed in the cockpit on an appropriate overlay map and will be available for controllers' use in monitoring aircraft on taxi, approach, departure, and en route.

Integration Issues:

- procedural issues for operational capabilities that are enabled by ADS (e.g. ATC separation)
- technical challenges with the air-to-air and air-to-ground data links to support ADS
- technical challenges combining ADS data with radar data
- human factors challenges with flight crew and controller's display

2. ***Increased flight information and communications in the cockpit (weather, terrain, obstacles, NOTAMS, SUA)***

Concept: Current and forecast weather information (graphic and text), such as graphical maps showing weather radar mosaic, lightning, icing and surface condition summaries, local terminal weather, and wind shear alerts, will be available via addressed or broadcast data link. Special Use Airspace schedules and NOTAMs will also be available via data

link. Terrain and obstacle information will be displayed to enhance the flight crew's situational awareness. Controller-Pilot data link communications via FANS will be available to equipped aircraft in selected geographic areas.

<u>Integration Issues:</u>

- development of procedures for operational capabilities that are enabled
- human factors challenges with display to flight crews and controllers

3. ***GPS enabled operational capabilities (approach guidance to all runways, precision missed approach guidance, more flexible arrival and departure routes, low altitude random direct routes)***

Concept: Low altitude GPS direct routes will be established between selected airports as well as procedures for random routes. Precision approaches, using GPS augmented with WAAS and barometric data, will be available for all airports capable of supporting them in the evaluation region, and nonprecision GPS approaches for all other runways. GPS arrival and departure routes and precision missed approach path guidance will also be provided for assistance in terrain avoidance.

<u>Integration Issues:</u>

- development of procedures for operational capabilities that are enabled
- human factors challenges with display to flight crews and controllers

4. ***Increased flexibility and efficiency of operations from enhancement of Decision Support Systems (DSS) in oceanic airspace***

Concept: Oceanic procedural separation decision support systems and dynamic track rerouting (DTR) functionality will enable more fuel-efficient routes across the ocean and provide flights with the flexibility to change routes mid-flight if winds are not as forecast. Improvements in the automation infrastructure will allow additional future enhancements.

<u>Integration Issues:</u>

- development of procedures related to oceanic routing flexibility enabled by certified decision support systems
- investigation of infrastructure improvements such as translation to modern programming language or use of non-developmental item (NDI) systems

2.1.4 Equipage

A number of aircraft in selected geographic areas of Alaska and Hawaii will be equipped with avionics enabling Automatic Dependent Surveillance - Broadcast (ADS-B); GPS navigation and approach guidance; and a multifunction display, processor, and data link supporting communications with ground facilities and display of flight information such as weather, terrain, and traffic. Specific areas of Alaska and Hawaii will have the corresponding ground infrastructure installed to support these capabilities.
An additional benefit of developing the new avionics required for Flight 2000 is the accelerated certification process and reduced cost for new avionics that may result, addressing the Task Force 3 near-term recommendation 12.

Aircraft equipped with avionics enabling FANS or ATN capabilities and ADS-B will be able to participate in Flight 2000 in the Oakland Center oceanic airspace. Key capabilities that will be available are ADS-A, ADS-B (air-to-air), and Controller-Pilot Data Link Communications (CPDLC). The ground infrastructure for Oakland's Oceanic Automation System will support ADS-A and CPDLC prior to Flight 2000, and decision support systems for procedural separation will be installed for Flight 2000. Ground automation to support CPDLC in Oakland's domestic airspace will also be installed.

2.1.5 Conclusion

The results of the Flight 2000 concept validation and integration activities will feed back into the *Free Flight Action Plan* initiatives and accelerate the development of operational improvements supporting free flight. Validated operational improvements will migrate from the specific Flight 2000 operational environment to the rest of the NAS.

2.1.6 Flight 2000 Operational Scenarios

The following four scenarios illustrate the concepts to validate in Flight 2000 at the next level of detail.

Scenario 1: Air Carrier Flight from CONUS - Honolulu

Overview

This scenario illustrates how more flexible routings will be provided for flights between the West Coast of the U.S. and Hawaii in Flight 2000. Controller-pilot data link communications (CPDLC) will facilitate more accurate and reliable communications between flight crews and en route and oceanic air traffic control (ATC). Optimum altitudes and speeds will be achieved through the expanded use of oceanic climbs and descents enabled by Automatic Dependent Surveillance - Broadcast (ADS-B). Flights will have the flexibility to change routes mid-flight if winds are not as forecast. Separation requirements will be reduced when within 75 minutes of entering Hawaiian surveillance coverage, allowing more efficient merging of traffic from multiple oceanic tracks onto arrival routes into Hawaii.

Operational Environment

The Flight 2000 initiatives relevant to this scenario will be implemented in a subset of the Oakland Air Route Traffic Control Center (ARTCC) airspace to include domestic sectors on the West Coast, transition sectors between domestic and oceanic airspace, and the oceanic sectors between the coast and Hawaii.

Oakland Center's oceanic traffic (i.e., over most of the Pacific Ocean) has a 10% growth rate per year, in addition to domestic traffic growth. Oceanic aircraft follow fixed or daily flex tracks between city pairs. The track structure is used to ensure safe separation by using "non-radar procedures." These procedures result in relatively large separation standards. The airspace structure limits the number of aircraft that can take advantage of favorable wind conditions and optimum altitudes. Altitude change requests by the flight crew to the ATC constitute the majority of all clearance requests in oceanic airspace. Controllers often cannot grant altitude clearances to domestic traffic because of priority given to oceanic traffic and because of separation constraints. Airlines carry extra fuel to account for such situations and thus reduce the amount of revenue generating cargo and passengers. Speed restrictions in oceanic environments are also implemented to assist the ATC in maintaining the separation minima. These large separation minima are the direct consequence of communications reliability and uncertainties in the position of the aircraft. In addition, oceanic controllers depend on manual marking of paper flight strips, a highly workload-intensive process, to maintain separation between aircraft.

Flight 2000 will incorporate a test bed for evaluating the proposed approach for eliminating flight strips as the primary means for separation determination. During the trials, one controller will maintain the flight strips' accuracy, while a second controller will be brought into the sector to operate a shadow operation from the secondary display. The shadow controller's time will be shared between responding to events (e.g., progress reports that are out of conformance or late, pilot requests for altitude or route changes, flight plan activations, and incoming and outgoing coordination messages) and monitoring the flow.

Operations

Controller-pilot data link communications will be used by appropriately equipped aircraft, with a smooth transition from domestic en route through the transition to oceanic airspace. In domestic and transition airspace, the data link messages will be used to augment existing voice radio; while in oceanic airspace, satellite data link will be used as the primary means of ATC communication. Both controllers and pilots will have access to both voice and data communications and will be provided with procedures to maximize the utilization of both means of communication.

The oceanic controller will separate aircraft from aircraft along the tracks between the West Coast and Hawaii which will already be laterally separated. Controllers will use the graphical and textual information on their displays to manage the traffic by exception for longitudinal and vertical separation. Conflicts will be probed for the entire flight when the flight plan is activated and when there is a change in the route or altitude. For equipped aircraft, ADS-A data will be used to more effectively and efficiently monitor aircraft position, and CPDLC will provide rapid, reliable communications with the aircraft. The caseload of events that require controller action will shrink

from today's caseload. The controller will spend more time planning for user requests, monitoring the flow picture, and re-verifying the separation picture because the decision support systems will allow the controllers to work much more efficiently.

The controller will monitor the flow picture using a graphical depiction of routes, fixes, aircraft locations and direction, and airspace boundaries. The controller will not be required to routinely read the position reports, instead when pilot estimates differ from the computer estimated fix crossing times, both times are presented to the controller. The procedural separation decision support systems will provide the controller with graphical and textual descriptions of head-on, lateral, longitudinal, crossing and convergence/divergence conflicts. The controller will determine the feasibility of the flight plan using all the data available, and will take action to modify the flight plan as necessary to meet planning needs and separation assurance. The controller will be able to modify the flight plan or will be able to contact the sector with executive control and request flight plan changes. The controller will also be able to annotate the flight for corrective action to be taken at a later time. The controller will also use tables of flight data to monitor the flow and separation picture. In addition to flow monitoring, the controller will use the aircraft table and fix tables to verify separation between aircraft and to plan for user requests. The conflict probe tool will perform trial probes as well as probes when aircraft report not as expected.

If updated weather forecasts indicate that the track system should be adjusted, more efficient tracks can be assigned through Dynamic Track Rerouting (DTR). The DTR process includes the following steps:

- The Track Management Unit (TMU) generates tracks based on updated weather forecasts. The TMU coordinates these tracks within ATC. These tracks are then forwarded to the Airline Operations Centers (AOC).

- The AOCs develop flight plans based on the new tracks. The flight plans are sent to the TMU and the cockpits and loaded into the Flight Management Computers (FMC).

- Each flight crew examines the DTR flight plan. If acceptable, the crew then requests a clearance from ATC to fly the new flight plan.

- Controllers receive and review each request and issue clearances, if appropriate

The controller will also plan for pending flights. Prior to an aircraft being activated, the controller will be able to project fix crossing times for pending aircraft based on the estimated boundary crossing times for the pending aircraft and on the actual flight progress of active aircraft using the same route of flight. Once activated, estimated flight progress will be available to the controller on the aircraft table and fix tables.

ADS-B will enhance the In-Trail Climb (ITC) and In-Trail Descent (ITD) procedures that have already been authorized on a trial basis for certain portions of oceanic airspace. The current procedures authorize the use of the Traffic Alert and Collision Avoidance System (TCAS) II traffic display for aircraft to climb or descend through the altitude of same direction traffic at separations considerably lower than standard non-radar separations, when certain display

adequacy requirements are satisfied and the required training has been accomplished. ADS-B may also enable additional procedures (i.e., Lead Climbs [LC], Lead Descents [LD], and station-keeping) to help aircraft to fly fuel-efficient altitudes.

Equipage

Participating aircraft will be equipped with FANS or ATN as well as TCAS. The Oakland ARTCC domestic automation system will be modified to incorporate CPDLC. (The oceanic automation system currently being developed will use CPDLC and ADS-A data, when available, to derive the track positions for participating flights for display and conflict probe functions.) Decision support systems will be provided to help the oceanic controller monitor aircraft separation and detect conflicts independent of aircraft equipage.

Procedures

Procedures for the use of data link in domestic and transition sectors will be developed. Mode C in domestic airspace will continue to be validated according to procedures contained in FAA Order 7110.65.

New oceanic separation assurance procedures will be tested to see if separation between participating aircraft can be safely reduced due to procedural separation decision support systems within 75 minutes of surveillance coverage for non-equipped aircraft and with the use of ADS-A and CPDLC for equipped aircraft. Procedures for using ADS-B to allow in-trail and lead climbs and descents will be developed and tested. For DTR, procedures will also be developed for controllers and pilots in use of separation systems, reporting frequency and content, contingency, and phraseology.

Transition to CONUS

Lessons learned in the use of CPDLC in Oakland Center en route airspace will benefit the implementation of similar procedures to other oceanic and domestic airspace. Experience gained in using ADS-B to aid separation during oceanic lead and in-trail climbs and descents, and station-keeping will accelerate introduction of ADS-B for use in other non-radar airspace. Experience with procedural separation of oceanic aircraft with reduced dependence on flight strips could lead toward free flight capabilities such as user-preferred routing in dense airspace.

Scenario 2: Part 135 Flight from Kahului - Honolulu

Overview

The second scenario illustrates a Part 135 flight from Kahului to Honolulu. The Part 135 aircraft is assumed to be a multiengine turboprop with standard existing equipment (i.e., transponder, VHF communications, and no FMS) and additional Flight 2000 equipage as specified below.

A traffic display on the integrated-multifunction display (I-MFD) will give an increased situational awareness of other equipped aircraft on the surface as well as in the traffic pattern. Traffic will be displayed in the cockpit on an appropriate airport overlay map. This will give the flight crew information to better evaluate the potential for runway and taxiway incursions, especially at night. Current and forecast weather information (graphic and text), such as graphical maps showing convective activity and surface condition summaries, local terminal weather, and wind shear alerts will be provided via addressed or broadcast data link. NOTAMs and Special Use Airspace (SUA) schedules will also be available via data link. Onboard terrain display will provide adequate terrain avoidance.

An ADS-B receiver and display will be installed at Kahului and Honolulu ATCTs for the tower controllers' use in monitoring aircraft during taxi and takeoff. An ADS-B receiver will be available to the Honolulu Flight Service Station and Part 135 dispatch facilities in Kahului and Honolulu for flight progress monitoring and emergency assistance. ADS-B surveillance data will be relayed to the Honolulu CERAP for flight monitoring in the case of radar service interruptions and to perform flight following during over-water route segments.

In-flight, traffic will be displayed, integrated with route and navigation information. Low altitude GPS direct routes will be established between Honolulu and other airports in the area. GPS precision approaches (CAT I, II, and III) will be published for Honolulu airport and precision arrival and missed approach path guidance will be provided. GPS CAT I precision approaches and nonprecision approaches will be published for all commercial airports. Terrain information will be displayed in the cockpit to assist in terrain avoidance during approach and departure operations.

In the Honolulu area, Traffic Information Service (TIS) is available to provide position information to ADS-B equipped aircraft for unequipped aircraft in the area.

Airspace

The primary airspace involved will be around Maui, Lanai, and Honolulu. Kahului has approximately 180,000 operations per year, of which 147,000 are air carrier or air taxi operations. Only 81 aircraft are based at Kahului. Radar approach control services are available. Gaps in radar surveillance coverage occur at low altitudes along the route from Kahului to Honolulu, requiring supplemental ADS-B coverage.

Equipage

Participating aircraft will be equipped with ADS-B, CDTI, and GPS. The Honolulu CERAP micro-EARTS will be modified to use both ADS-B and radar data, when available, to derive the track positions for participating flights. A ground ADS-B receiver and display system will be installed at Honolulu and Kahului towers.

Flight Information System (FIS) equipment will be installed at the Honolulu Flight Service Station (FSS) to provide FIS services to aircraft via data link.

Local Area Augmentation System (LAAS) will be installed at Honolulu to provide precision GPS approach services for equipped aircraft. This precision positioning information will also be used to display aircraft positions on an airport surface moving map display.

Procedures

The integration or selection of traffic, navigation, and terrain information on a cockpit display will be investigated. Operational issues related to combining ADS-B and radar data for display to controllers will be addressed and procedures developed. GPS routes and approaches will be developed and published for use at all commercial airports. Procedures for use of GPS augmentation to achieve CAT III precision approach capability will be developed and appropriate cockpit systems developed and certified.

Transition to CONUS

The development of workable cockpit procedures and automation to select or integrate traffic, navigation, and terrain information for display to the flight crew without interference with their primary flight tasks will be a valuable contribution that will be applicable to all CONUS operations. The development of procedures for GPS precision approaches and certification of avionics will accelerate the use of GPS precision approaches in CONUS and result in safer operations and greater capacity during low IFR conditions at many airports.

The development of workable cockpit procedures and automation to select or integrate weather, traffic, and terrain information for display to the flight crew without interference with their primary flight tasks will be a valuable contribution that will be applicable to all CONUS operations. Experience in using ADS-B for separation assurance and traffic information in a mixed equipage environment will also accelerate the use of ADS-B in CONUS.

Scenario 3: Part 135 Flight Bethel Round Robin

Overview

The third scenario illustrates a Part 135 flight from Bethel to Kipnuk, to Mekoryuk, to Hooper Bay, and then back to Bethel. The Part 135 aircraft is assumed to be a multi-engine turboprop, standard existing equipment (i.e., transponder, VHF communications, no FMS), and additional Flight 2000 equipage as specified below.

Traffic display on the integrated-multifunction display (I-MFD) will give an increased situational awareness of ADS-B equipped aircraft on the surface (at Bethel and possibly other airports) as well as in the traffic pattern. Traffic will be displayed in the cockpit on an appropriate airport overlay map. This will give the flight crew information to better evaluate the potential for runway and taxiway incursions, especially at night and in low visibility conditions. Current and forecast weather information (graphic and text), such as graphical maps showing icing and surface condition summaries, local terminal weather, NOTAMs and wind shear alerts, will be available via addressed or broadcast data link. SUA schedules will also be available over data link. Both SUA schedules and local weather observations will be available by voice recording over VHF

radio. These flight information services (FIS) will be provided by the Kenai FSS, and service will be limited to aircraft within line-of-sight coverage for voice communication, and within coverage of the transmission mechanism used for data link. Since Bethel is located in a relatively flat geographical area, coverage down to altitudes at or near the surface is possible.

An ADS-B receiver and display will be installed at Bethel for the tower controllers' use in monitoring aircraft on taxi, approach, or departure (similar to a BRITE display). ADS-B equipped aircraft may be segregated (by airspace design or time period) from unequipped aircraft during test periods for safety reasons. Each aircraft equipped with ADS-B will now have the added safety benefit of a ground controller monitoring its progress during approach and departure. ADS-B surveillance data will also be relayed to Anchorage ARTCC for use in monitoring aircraft under ARTCC control, especially those performing instrument approaches into Bethel, resulting in an increased arrival rate during special VFR or IFR conditions.

ADS-B receiver sites will be established at area airports such as Hooper Bay, Mekoryuk, Kipnuk, Aniak, St. Marys, and Emmonak. ADS-B surveillance data will be relayed to Bethel for display to controllers for flight following and emergency assistance and auxiliary displays will be available for Part 135 dispatchers for monitoring their flights' progress.

Airspace

Participating aircraft will operate at the Bethel and surrounding area airports, and all connecting routes. Approximately 55,000 commercial and air taxi operations per year occur at Bethel. Bethel is a part-time contract tower controlled (Class D) airport area, otherwise uncontrolled (Class E). The connecting routes and area airports are Class E and Class G airspace. Surveillance coverage based on radar exists in portions of the en route and terminal airspace, but for the most part, does not exist at lower altitudes.

Equipage -- Airborne

Participating aircraft will be equipped with I-MFD (traffic, weather, terrain and obstructions, moving map, etc.), ADS-B, GPS/WAAS/LAAS, and data link capability. Most of the aircraft operating in the environment described in this scenario are so-equipped; however, there may be a few aircraft that are not fully equipped with the avionics suite specified above, in particular ADS-B.

Equipage -- Ground-Based

A ground ADS-B receiver and display system will be installed at Bethel. ADS-B receivers and satellite links will be installed at surrounding area airports such as Hooper Bay, Mekoryuk, Kipnuk, Aniak, St. Marys, and Emmonak.

The Anchorage ARTCC automation system will be modified to use both ADS-B and radar data, when available, to derive the track positions for participating flights.

The ADS-B receiver sites established at area airports will collect ADS-B surveillance data, which will be relayed to Bethel for display to controllers for flight following and emergency assistance. These data will also be routed to auxiliary displays, which will be available for Part 135 dispatchers for monitoring their flights' progress, and for FSS to conduct search and rescue operations.

FIS communication equipment will be installed at Kenai (FSS) to provide services to aircraft operating in the Bethel terminal area and surrounding airspace. Service coverage down to the surface at surrounding airports may be provided by additional communication equipment installed at these airports. FIS information will be provided by the FSS by voice communication as well.

TIS will not be a service provided in this airspace.

LAAS will not be installed at Bethel, and WAAS will be used for instrument operations (en route, terminal, and approach/departure). Precise surface navigation will not be a service provided at Bethel or surrounding areas, although positioning information may be available using GPS/WAAS on the airport surface. Taxi route on the surface may be monitored using the I-MFD.

Approach minima are expected to be approximately 250' and 1/2 mile for Category I precision approach, assuming the WAAS is implemented and operates as specified. Otherwise, minima will be higher.

Procedures

Low altitude GPS direct routes (i.e., not based on existing airways) will be established between Bethel and other airports in the area. Offsets may be used (e.g., .5 nmi offset to the right from the centerline of the route) for conflict avoidance.

Precision (3-D) approaches based on augmented GPS (WAAS) TERPS will be published for Bethel, and nonprecision (2-D) approaches based on TSO C-129 GPS TERPS will be published for Bethel and all paved and unpaved runways in the Bethel area (within 150 nmi) suitable for instrument operations.

3-D arrival and missed approach path guidance will also be provided to begin developing terrain avoidance procedures for new GPS arrival and departure routes (i.e., not based on existing routes.) The Bethel area provides a benign environment for developing procedures for terrain avoidance.

New separation assurance procedures by ATC will be tested to determine the extent to which separation between participating aircraft can be safely reduced from non-radar standards using enhanced surveillance coverage via ADS-B position reports. The relationship between separation requirements and ADS-B position report frequency and accuracy will be explored.
The integration or selection of traffic, weather, and terrain information on a position display will be investigated. Course deviation indicators and altitude/glide slope information is expected to be displayed on a dedicated device in the primary field of view, consistent with existing navigation procedures, although the pilot interface and avionics operation will be different from existing

navigation systems (e.g., VOR, ADF, GPS TSO C-129 avionics). It is also possible that this primary flight guidance information will be integrated onto the I-MFD as well.

Operational issues related to combining ADS-B and radar data for display to controllers will be addressed and procedures developed. GPS routes and precision arrival, approach, and missed approach procedures will be developed and published for use in the Bethel area. Additional staffing may be required at the Bethel ATCT to perform the additional task of flight following and monitoring the traffic display for arrivals and departures.

Controller-pilot communication in this scenario is expected to continue based on existing procedures (i.e., CPDLC is not intended for use in this scenario in the 2000 time frame). Since aircraft operators/pilots will have cockpit displays of weather, reduced workload associated with switching communication frequencies, contacting Flight Service, listening to automated weather reporting systems, etc., will allow the opportunity to explore the capabilities of the I-MFD and increase situational awareness. Additionally, if Part 135 dispatch operators are provided with surveillance coverage displays, this may eventually reduce the required voice communication between aircraft operators and dispatch.

Emergency procedures may be initiated based on the most recent broadcast via ADS-B, as well as by conventional means via the Mode C/S transponder.

Transition to CONUS

Lessons learned in developing new separation procedures, determining required position report rates for given separation requirements, and combining ADS-B and radar data for display to air traffic controllers will accelerate the expansion of surveillance coverage in CONUS and oceanic airspace using ADS-A and ADS-B.

The development of workable cockpit procedures and automation to select or integrate weather, traffic, and terrain information for display to the flight crew without interference with their primary flight tasks will be a valuable contribution that will be applicable to all CONUS operations. Experience in using ADS-B for separation assurance and traffic information in a mixed equipage environment will also accelerate the use of ADS-B in CONUS.

Scenario 4: General Aviation Flight from Anchorage to Nome

Overview

This scenario illustrates a general aviation flight from Anchorage to Nome. The general aviation flight is assumed to be conducted under Part 91, single-pilot IFR, using a single-engine piston aircraft with minimal existing instrumentation (i.e., VOR, ADF, Mode C transponder, and VHF communication), as well as additional Flight 2000 equipage as specified below. Nome is a relatively smaller airport, with about one-third the number of operations and based aircraft as that of Bethel. There is an Flight Service Station (FSS) on the field at Nome, however.

Traffic information displayed on the integrated-multifunction display (I-MFD) will provide the flight crew with an increased situational awareness of other ADS-B and transponder equipped aircraft on the surface as well as in the traffic pattern at Anchorage. This is accomplished by display of integrated ADS-B and Traffic Information System (TIS) information.

The I-MFD will also include an airport overlay map, terrain and obstruction information, and weather. This will give the pilot information to better evaluate the potential for runway and taxiway incursions, and flight into icing or other dangerous weather conditions, especially at night. Current and forecast weather information (graphic and text), such as graphical maps showing icing and surface condition summaries, local terminal weather, NOTAMs and wind shear alerts, will be available via addressed or broadcast data link. Special Use Airspace (SUA) schedules will also be available over data link. Both SUA schedules and local weather observations will be available by voice recording over VHF radio.

An ADS-B receiver and display will be installed at Anchorage ATCT for the tower controllers' use in monitoring aircraft during taxi and takeoff. An ADS-B receiver will be installed at Nome, and ADS-B surveillance data will be relayed to the Anchorage ARTCC for use in monitoring IFR approaches and VFR flight following and emergency assistance.

In-flight, traffic will be displayed on an I-MFD, integrated with route and navigation information. Low altitude GPS direct routes will be established between Anchorage and other airports in the area. GPS precision approaches (CAT I, II, and III) will be published for Anchorage and precision arrival and missed approach path guidance will be provided. GPS CAT I precision approaches and nonprecision approaches will be published for all commercial airports. Terrain information will be displayed in the cockpit to assist in terrain avoidance during approach and departure operations.

Airspace

The airspace involved will be between Anchorage and Nome. Anchorage is a terminal area, with multiple runways and medium capacity operations under Class C type airspace. Nome is a non-tower-controlled airport area (Class E/G). The connecting airspace between the Anchorage Class C airspace and Nome is Class E and Class G airspace. Surveillance coverage based on radar exists in portions of the en route and terminal airspace, but for the most part, does not exist at lower altitudes. The controlling en route facility is the Anchorage ARTCC for the entire route of flight.

Equipage -- Airborne

Participating aircraft will be equipped with I-MFD (traffic, weather, terrain and obstructions, moving map, etc.), ADS-B, GPS/WAAS/LAAS, and data link capability. Most of the aircraft operating in the environment described in this scenario are so-equipped; however, there may be a few aircraft that are not fully equipped with the avionics suite specified above, in particular ADS-B.

Equipage -- Ground-Based

Ground ADS-B receivers and a display system will be installed at Anchorage. An ADS-B ground receiver and satellite link will be installed at Nome and selected sites along the route from Anchorage to Nome.

The Anchorage ARTCC automation system will be modified to use both ADS-B and radar data, when available, to derive the track positions for participating flights.

The ADS-B receiver sites established will collect ADS-B surveillance data, which will be relayed to Anchorage for display to controllers for flight following and emergency assistance. These data will also be routed to FSS sites along the route to conduct search and rescue operations.

Flight Information System (FIS) communication equipment may be installed at Nome (FSS) to provide services to aircraft operating in the Nome terminal area and surrounding airspace. FIS information will be provided by the FSS by voice communication as well.

TIS will not be a service provided in this airspace, except for the Anchorage area.

LAAS will be installed at Anchorage, and LAAS will be used for instrument approach and departure operations at Anchorage. Elsewhere, en route to Nome and at Nome, GPS/WAAS will be used for navigating

Precise surface navigation will not be a service provided at Nome or surrounding areas, but will be available at Anchorage. GPS/WAAS may be used for positioning on the airport surface at Nome, if available. Approach minima are to be determined at Nome, based on the performance of GPS/WAAS at that location. Approach minima for Cat I at Anchorage are expected to be approximately 250' DH and 1/2 mile visibility.

Procedures

The integration or selection of traffic, navigation, and terrain information on a cockpit display will be investigated. Operational issues related to combining ADS-B and radar data for display to controllers will be addressed and procedures developed. GPS routes, precision approaches, and precision missed approach procedures will be developed and published for use at all commercial airports. Weather display to avoid Controlled Flight Into Terrain (CFIT) accidents will be a focus of this scenario. Procedures will be developed for CFIT avoidance during both IFR operations, and VFR operations during which IMC conditions (and terrain/obstacles) are unintentionally encountered.

Transition to CONUS

The development of workable cockpit procedures and automation to select or integrate traffic, navigation, weather, and terrain information for display to the pilot, without interfering with primary flight tasks, will be a valuable contribution that will be applicable to all CONUS operations.

The development of procedures for GPS precision approaches and certification of avionics will accelerate the use of GPS precision approaches in CONUS and result in safer operations and greater capacity during low IFR conditions at many airports.

2.2 Operational Improvements To Be Validated

2.2.1 Flight Planning Improvements

Improved Weather Access

The aircraft pilot or dispatcher needs to be able to access a data base of weather information that is as close to real time as possible. This will be performed during pre-flight using a personal computer-based system where he or she can access the types of weather that are applicable to the proposed flight. Though some of this data certainly does exist on the ground today, the detail, timeliness and accuracy of the data will be improved. Types of weather reports include the International Meteorological Aviation Report Format (METAR), International Terminal Area Forecast Format (TAF), Runway Visual Range (RVR) Trend Data, Radar Summaries, Lightning Strike Maps, Pilot Reports (PIREP), and infrared and visible satellite imagery including loop movies of the latest images. The user will be able to tailor the request to specific destinations, airway segments or point-to-point segments. The system will allow for the user to request single or multiple types of reports. Timeliness of the data will be included on each report.

The pilot also needs to access this same data base from the cockpit. Aircraft will be equipped with suitable displays of sufficient size to aid in the decision-making process of initiating, continuing or diverting a flight. Two types of displays are envisioned: text only or graphical with text. Depending upon the aircraft's display capability, weather products will be tailored to suit the users. The resolution of these displays will be capable of supporting the numerous lighting conditions of flight. Input mechanisms and the human interface will take into account turbulent weather conditions. Options for a one time request or a continuous or contracted update schedule will also be desirable options for the pilot in the air.

Improved Access to Special Use Airspace Information

Aircraft operators need to be able to access information which provides a real-time status and schedule of Special Use Airspace (SUA). SUA consists of airspace wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not part of these activities. SUA includes restricted areas, prohibited areas, military operations areas, alert areas, national security areas, controlled firing areas, and off shore warning areas. Although military training routes are not specifically designated as special use airspace, knowledge of military traffic on these low-altitude, high-speed tracks would enhance safety to other air traffic flying near them. During flight planning, this SUA information will be provided through a personal computer connection to a central site which maintains an up-to-date status of all SUA. The data base at this site will contain each SUA identifier, the activation and deactivation times and altitudes, current status and altitudes in use. An interactive software tool

will enable the planner to query a particular SUA, to search a variable radius around a given point, or to look at a certain distance along a route or point-to-point input.

In flight, a pilot also needs to be kept up to date on the status of this airspace. Cockpit text or graphic displays and a data link to the SUA data base will enable the pilot to maintain an up to the minute status of all hazardous areas near the flight path and fly a route which will be the most efficient and safest.

Another opportunity for increased benefits in the longer term is to improve the automation available to the ground controller such that flight plans will be able to be modified once an aircraft is en route and a restricted area becomes available for transit of commercial or general aviation traffic. This will allow for real time changes and direct routings to destinations rather than the roundabout paths currently taken.

2.2.2 Airport Surface Operations Improvements

Reduced Taxi Delays in Low Visibility Operations

Users and service providers need the capability to maneuver aircraft on the airport surface during periods of reduced visibility. Control tower personnel will be capable of assisting an aircraft on the ground with taxi directions using technology which has sufficient accuracy to determine the position of the aircraft within 3 meters. The controller display will provide aircraft identification, type, heading and ground speed across the entire airport surface. Automation supporting the display will have capabilities for detecting aircraft to aircraft and aircraft-to-ground object conflicts. Properly equipped ground vehicles in the active taxi region will also be tracked and monitored. Automation may also allow for activation and deactivation of airport surface lighting based upon aircraft position and direction of movement.

Aircraft will also be able to monitor the positions and direction of movement of their aircraft and other aircraft and ground vehicles in their vicinity. A cockpit display will provide the same 3 meter positional resolution of all objects and present the desired taxi routing

Real-Time Airport Weather via Data Link

The aircraft operator needs to be able to access a data base of weather information that is as close to real time as possible. This information is necessary in all phases of flight including on the airport surface while preparing for departure. The information required for this phase will include runway visual range (RVR) trend data, windshear information, and precipitation intensity within a 20-30 NM range of the airport. The user will be able to tailor the request to certain types of products including weather information away from the airport of departure and along the planned route of flight. Text and graphical displays will be used to display the data.

2.2.3 Departure and Arrival Improvements

Satellite-based Departure and Arrival Routes

With the transition from ground-based to space-based navigation, aircraft operators will need to execute departure and arrival procedures without loss of the functional capability and safety resident in today's system. GPS-based departures and arrivals can be designed to be more efficient than those based upon fixed site ground navigation aids. Current procedures are based around flying on fixed radials or distances from these fixed sites. A GPS position is relative to an earth coordinate system. Most current departures and arrivals are based upon positions relative to fixed ground sites, often away from the intended point to where the aircraft needs to go. Many approaches and departures require switching between ground navigation aids during these critical phases of flight. GPS approaches can be pre-programmed into the receivers and displayed in a dynamic map format, increasing the pilot's situational awareness of where the aircraft is in relation to the desired flight path. Since no navigation aid frequency changes need to be made, the pilot can concentrate on flying the aircraft safely and efficiently.

Improved Terminal Area Weather Information

Arrival and departure phases of flight are when aircraft are most susceptible to the threat of severe weather. Windshear, heavy rain, hail, microbursts, reduced visibility, and turbulence are examples of weather phenomena which can quickly put an aircraft which is operating close the ground into a dangerous situation. These phenomena can present risks in other phases of flight, but there the pilot has more time and more options available to get away from the hazardous conditions. Graphical and text weather products will be relayed to the cockpit via data link to provide a real time weather alerting system. Real-time severe thunderstorm and tornado warnings, runway surface conditions, wind shear and heavy precipitation alerts are just a few of the terminal area weather products which will be provided.

Increased Pilot Situational Awareness/Decreased Visual Approach Minima

Situational awareness is knowledge about one's surroundings and intentions. For a pilot, this includes a knowledge of the aircraft's status and condition as well as the environment external to the aircraft. Aircraft status includes propulsion information such as engine speed, temperatures, pressures and quantities; airframe information such as fuel quantity, flap position, landing gear position, radio and navigation aid status, autopilot mode, flight director mode, ice accumulation, hydraulic system status, and electrical system status; and performance information such as airspeed, altitude, rate of climb or descent, heading, and attitude. The pilot must also be aware of the external environment including knowledge of terrain, weather, other aircraft in the vicinity, the aircraft's position relative to the intended flight path, and upcoming changes which will need to be made to the flight path due to controller direction or pre-planned routing.

Any improvements which can be made to increase a pilot's situational awareness will have a direct effect on increased safety and operational efficiency. Flight management systems, heads-up displays and glass cockpit displays have all been widely accepted because of their impact on

improving situational awareness. New technologies will enable even more enhancements in this area.

Currently, much of a pilot's situational awareness comes from what he or she can synthesize from listening to voice communications. A mental picture is formed of what the pilot thinks is going on external to the aircraft. Data link and onboard digital systems have the ability to directly increase awareness of the external environment by providing visual products into the cockpit. Alaskan operators have a much higher incidence of controlled flight into terrain (CFIT) than those in other areas due to the abundance of mountainous terrain, lack of radar coverage and poor weather conditions. An onboard data base of three dimensional terrain information will be referenced using the aircraft's GPS position and a graphical display produced which will show the pilot the outside world even if weather constrains inflight visibility. This same terrain data base will provide the user with the information required to conduct visual approaches into airports with decreased approach minimums. Using accurate aircraft positional information referenced to the airport environment, the pilot may land at airports in bad weather with a similar situational awareness available on a clear weather day.

Increased Surveillance Coverage

To provide separation of aircraft in flight, the service provider must have surveillance capabilities to track aircraft. Surveillance today is provided by using primary and secondary surveillance radars. Primary radars use the reflection of energy of an aircraft's skin to track targets. Secondary radars require a transponder aboard the aircraft which replies to the radar interrogation with aircraft identification and selected flight data such as aircraft altitude, depending on the type of transponder. These systems are limited in their surveillance capability in areas where terrain or distance prevent the line of sight transmission of energy between the radar and the aircraft. These systems are also costly to procure and maintain. This is the reason many portions of Alaska do not have radar surveillance coverage.

To improve surveillance coverage will require the introduction of dependent surveillance, a method where aircraft positional and velocity data (relative to a world coordinate system such as derived from GPS) is transmitted via a dedicated link. This data can be received by other aircraft or by ground stations. Aircraft equipped to receive the broadcast can process the data and provide a situation display of all dependent surveillance equipped aircraft in their proximity. Air traffic controllers will have increased awareness of aircraft positions and intentions in those areas of non-radar coverage. This will provide increased approach and departure efficiencies and safety.

2.2.4 En route and Cruise Improvements

User Preferred Trajectories, Schedules and Flight Sequences

The ability of airspace users to dynamically select the optimum route and altitude will be enhanced by improved communications, navigation and surveillance technologies and revisions to air traffic management procedures that assure positive separation of aircraft while maximizing aircraft performance and flight path flexibility. Increased approval of operator preferred routes will result

in self-optimized flight operations and costs. These benefits will be brought about by satellite based, high accuracy positional information and controller decision support systems.

Increased Air-Ground and Air-Air Surveillance Coverage

Surveillance is provided in the en route phase of flight much the same as in the approach and departure phases. Primary and secondary surveillance radars are used by the controller to provide aircraft separation. The only air-to-air surveillance capability exists in large passenger transport aircraft equipped with the Traffic Alert and Collision Avoidance System (TCAS).

The introduction of dependent surveillance will greatly increase the air-to-air surveillance capabilities and expand air-to-ground surveillance coverage in areas where radar coverage is not available. This expanded coverage has the benefits of providing additional aircraft separation services in non-radar environments, both by air traffic controllers and by aircraft operators in uncontrolled airspace, providing aircraft track information for use in missing aircraft or search and rescue operations, and providing a source of aircraft position and flight data when primary or secondary radar coverage is not available.

Hazardous Weather Avoidance

Thunderstorms often develop in altitudes well above the service ceiling of jet aircraft. Heavy rain, hail, icing, violent updrafts and downdrafts, and extreme turbulence are common characteristics of these storms at all altitudes. Turboprop aircraft operating at mid-altitudes are even more susceptible to these storms. General aviation aircraft are the least prepared to encounter these dangerous conditions due to their limited performance capabilities and generally less capable weather avoidance avionics such as weather radar.

Clear air turbulence can also be hazardous to aircraft, aircrews and passengers. It is impossible to detect with satellite or ground-based sensors. Usually its presence is known only by an aircraft flying into the condition. Pilot reports, when passed to controllers, do not provide other aircraft in the area with enough details of the encounter to be effective in preventing additional occurrences.

Data links of real-time weather information to the cockpit could alleviate some of the hazards encountered during the en route phase of flight. Maps of exact locations and altitudes of clear air turbulence reports will be much more helpful to pilots approaching the area. Lightning strikes, heavy rain, tornado activity and other thunderstorm phenomena plotted on a moving map display will greatly assist the pilots in avoiding these hazardous conditions.

Increased Pilot Situational Awareness

The situational awareness discussion presented in the departure and approach phase of flight has similar application to the en route phase. Pilots must continually be aware of their aircraft and their surroundings to maintain a safe and efficient flight profile. In Alaska, the en route phase may be even more critical than the departure and arrival phases in that the aircraft may be out of radar coverage and communications contact with anyone on the ground. The pilot can be limited to the

systems onboard the aircraft for gaining information upon which situational awareness is based. Data link products such as updated weather information, surveillance products such as broadcast positions of other aircraft and onboard system products such as nearby terrain depiction will increase the pilot's situational awareness resulting in improved safety.

Use of Low Altitude Direct Routing Using GPS

Current procedures and practices result in aircraft, generally general aviation aircraft operating under instrument flight rules (IFR), being routed around major terminal areas, significantly increasing flight mileage and fuel consumption. This is particularly true in areas where several large airports are located in close proximity, such as the island of Oahu. Ground-based navigation aids do not allow the flexibility to establish safe and efficient routings to accommodate these aircraft transiting these high-density areas. Low-altitude direct routes based upon GPS navigation will offer the benefits of reduced flight mileage, reduced fuel consumption, reduced flight time and increased safety through the establishment of a minimum obstacle clearance altitude (MOCA) and minimum en route altitude (MEA) for each route. These routes will be established such as to not conflict with the normal arrival and departure flows for each runway configuration used by the airport(s). Development of these routes will be accomplished similarly to those conducted previously to establish the current VFR corridors in use in major terminal areas. Procedures will be developed to handle traffic on these routes by each affected facility.

The use of GPS as the means of navigation will make these low-altitude routes especially beneficial in non-radar areas such as Alaska, where navigation coverage is normally inferior to that found in radar environments. Aircraft operators operating under IFR rules in instrument meteorological conditions will be able to navigate on GPS-defined routes where ground navigation aids do not exist.

2.2.5 Oceanic Improvements

Increased Capacity Through Reduced Separation Minima

Separation of aircraft in the oceanic domain is performed today mainly by procedures necessitated by difficulties in determining aircraft position and intent without radar coverage and immediate voice communications. Some improvements have been made recently with the advent of the Future Air Navigation System (FANS) which includes GPS navigation and oceanic data link via satellite communications. These improvements provide the oceanic controller an accurate and reliable position as well as the ability to more quickly communicate with the aircraft. Improved procedures are also enhancing oceanic operations by allowing aircraft operators more flexibility in their selection of routes and altitudes.

Further reductions in separation minima will require technology improvements in aircraft position surveillance, air-to-ground communications, controller decision support systems and procedures to enable these capabilities.

Dynamic Rerouting and Optimum Altitude Availability

The ability to grant an individual aircraft a change to its route and/or its altitude will result in reduced air miles and more optimal matching of aircraft performance to its environment, thus reducing fuel consumption, flight time and, ultimately, costs. Accomplishment of this improvement will depend upon improved communications, navigation and the ability of the controller to identify possible conflicts with other aircraft downstream. Communications improvements will include data links via HF, VHF and satellite channels.

Dynamic Route Structures and Flexible Tracks

The benefits of using flexible tracks in the oceanic environment are to offer the user preferred routes, which will provide reductions in flight time and fuel consumption. As the preferred routes are granted early in the flight, less interaction will need to occur between pilots and controllers to process clearance change requests, resulting in reduced workloads on the ground and in the air.

3.0 Flight 200 Service Architecture

The Flight 2000 service architecture is constructed around the operational concept and the challenge presented by the White House Commission on Civil Aviation Safety and Security recommendation to modernize the National Airspace System (NAS) by 2005. The Flight 2000 operational evaluation represents an essential step toward full modernization of the NAS. Evaluations selected are designed to verify communications, navigation, surveillance, and decision support systems which will serve well into the 21st Century. The service architecture describes what services will be provided, how they will be provided, and what operational improvements are to be evaluated during Flight 2000. An important element in Flight 2000 is the need to implement free flight enabling technologies so as to remove limits on the FAA's ability to meet the needs of a growing aviation industry.

The Flight 2000 architecture is a subset of the NAS Architecture currently under development by the FAA that describes how the NAS will transition to provide improved safety, efficiency, capacity, flexibility, and access. Flight 2000 provides an opportunity to reduce risk in the overall NAS architecture and allow the FAA to more closely estimate cost and schedule for full modernization.

3.1 NAS Service Model

Figure 3.1-1 shows the top-level NAS service categories, which encompass the breadth of the NAS. The majority of the operational evaluations in Flight 2000 relate to air traffic services and are highlighted in Figure 3.1-2. A significant element of Flight 2000 involves avionics and streamlining of certification. Avionics certification processes are currently being streamlined and will be available prior to start of Flight 2000. The service model provides traceability to existing and planned NAS documentation developed for the NAS Architecture.

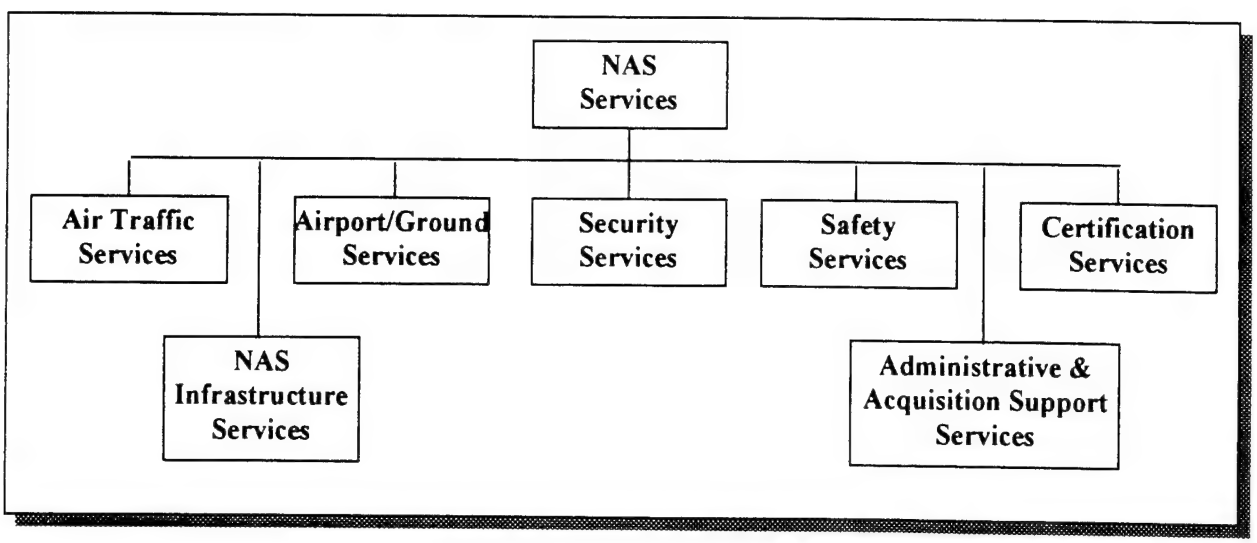


Figure 3.1.
NAS Service Model

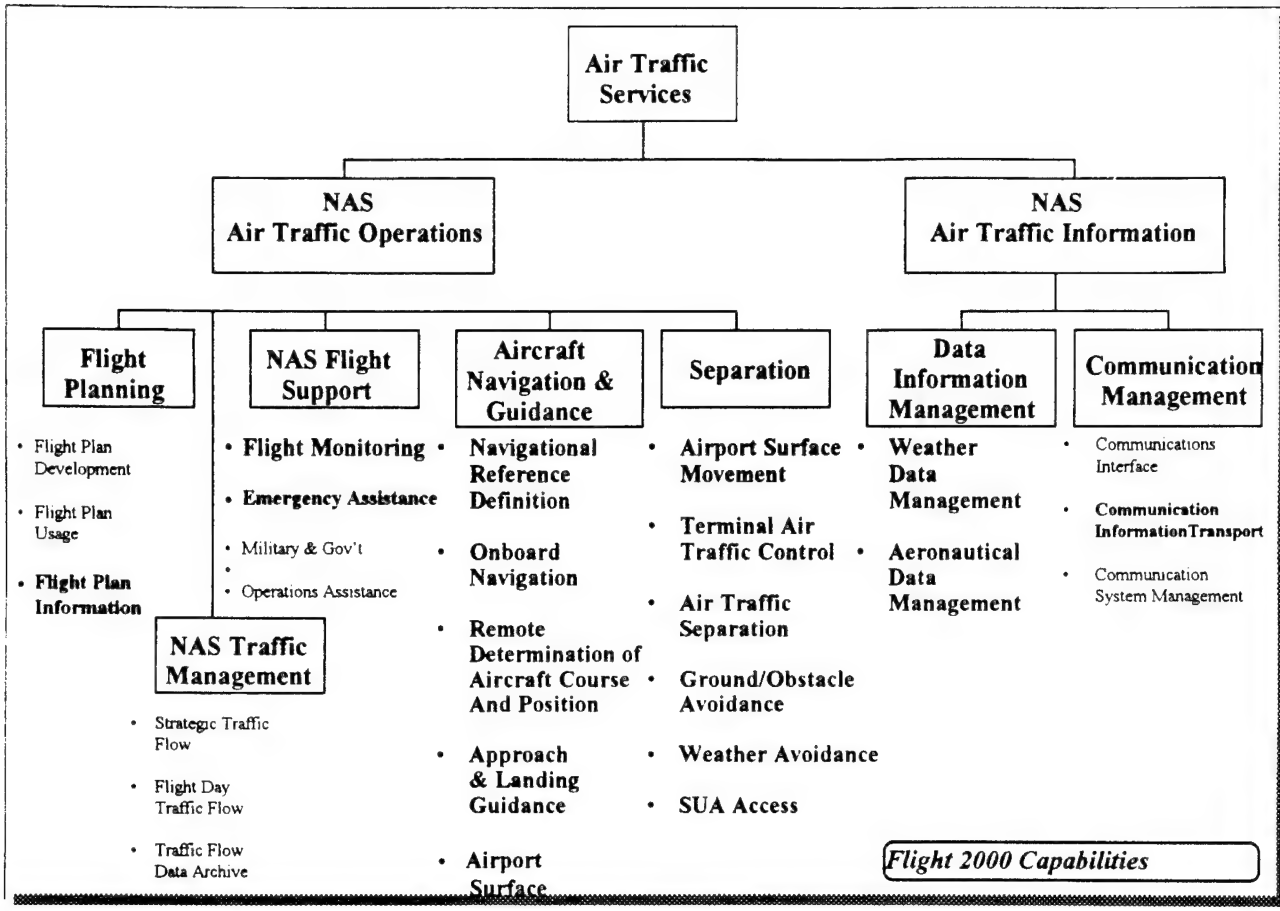


Figure 3.1-2.
Air Traffic Services

3.2 Structure of Flight 2000

For planning and management of Flight 2000, service operational evaluations will be grouped into three categories. Each category is conducted with opportunities to add operational benefits based on completed development of procedures or the maturity of the capability.

3.2.1 Three Parallel Tiers of Flight 2000

Services are divided into Tier I, II, and III evaluation activities. Table 3.2-1 summarizes the characteristics and provides examples of each category. Assuming funding for Flight 2000 in Fiscal Year 1998, then Tier I services would be September 30, 2000 with the exception of some GPS approaches, which will be commissioned earlier, and will provide an early evaluation using a limited number of aircraft.

Table 3.2-1
Description of Three Parallel Tiers for Flight 2000 Capabilities

Tier I	Tier II	Tier III
Characteristics		
• Opening day services provide immediate benefits • Limited ATC procedural changes needed • Advisory weather services available	• Improvements are operational after 6-8 months of evaluation • Evaluations and data collection necessary to develop procedures • Mature technology in avionics is available • Integration testing is needed to select best options for use in the entire NAS • Technology is expected to mature before 2005	• Considerable performance uncertainties • Certification issues where FAA data collection can help industry • CRDAs and other industry /FAA partnerships for technologies that could be expected between 2003-2008 • Partnerships on enhancements beyond Flight 2000 where a test bed will help make decisions on the future NAS
Examples		
• GPS approaches • Weather to the pilot via data link • Avionics installed	• Use of ADS-B for separation • Enhance conflict probe in the ocean • Controller/pilot comm using data link	• Satellites for air/ground comm

Tier I equipment will be installed, communications tested, and services readied for use. Human factors issues relating to presentation of information and performance of avionics will be resolved, and the avionics will be certified. Assuming funding in Fiscal Year 1998, avionics will be installed in the winter and spring of 1999-2000. Limited demonstrations will be conducted, leading to wider service availability starting September 30, 2000. Tier II will add new services as evaluations are completed.

Tier III evaluation activities will be unique cases, using limited sets of avionics or ground systems to test and prove capabilities. Some of the testing during this phase will be conducted by William J. Hughes Federal Aviation Administration Technical Center (FAATC) or at selected NASA facilities. Where activities show direct operational improvement they will be implemented as a new service in Flight 2000 or planned as part of NAS modernization.

3.2.2 Capabilities of Flight 2000

The new or improved capabilities to be provided by Flight 2000 are directly traceable to the operational concept for the NAS modernization for 2005. Table 3.2-2 provides a mapping of operational improvements presented in Chapter 2 to the new or improved capabilities to be provided by Flight 2000. The qualitative benefits to both the FAA and NAS user are included in the mapping

Table 3.2-2
Operational Improvements with Enabling Capabilities and Benefits - (Part 1)

Operational Improvement	Enabling Capability	Benefits
2.0 PREFLIGHT PLANNING	•	•
2.2. Improved weather access,	• Distribution of weather products to flight service stations • Improved access to information • in the cockpit: • via voice flight service station, • via data link (in line of sight) in text and/or graphical form • Internet access of flight service information	• Allow pilots to: • Avoid bad weather • Monitor changing weather conditions • Optimize flight operations • Reduces FAA workload in planning and communications • Parity of weather information for pilots and controllers collaboration
2.3. Better and more rapid access to Special Use Airspace (SUA) information,	• Interface to SAMS/MAMS for FSS's • Data link of SUA information in cockpit • Internet access of flight service information	• Increase access through real-time use of airspace • Increase flight flexibility
2.4. Improved coordination among TFM, ATC, and users	• Data link of NOTAMS and SUA via FIS Processor • Use of ADS-B by FSSs for traffic advisories	• Improved flight planning through increased awareness of NAS status and associated restrictions

Table 3.2-2
Operational Improvements with Enabling Capabilities and Benefits - (Part 2)

Operational Improvement	Enabling Capability	Benefits
3.0 AIRPORT SURFACE		
3.1 Reduced communication and coordination activities through the expansion of data link capabilities to more airports	• Provide Digital - Automatic Terminal Information Service (D-ATIS)	• More rapid and accurate communication of flight information • Reduced communication congestion
3.3 Improved safety through more accurate and reliable surface detection capabilities and display of surface traffic in the tower and in the aircraft	• Accurate presentation of aircraft during ground movement enabled by ADS-B, multilateration, ASDE-/AMASS in tower and cockpit display of traffic	• Reduction of runway incursions • Improves situational awareness
3.4 Improve pilot situational awareness	• Cockpit display of surface situational information, including surface surveillance via ADS-B • NOTAMS available cockpit	• More efficient and safer surface movement
3.6 Reduced taxi delays in low visibility operations	• Improved surface situational awareness in tower and cockpit via ADS-B, multilateration, ASDE-3, and AMASS	• Increased efficiency of surface movement in instrument meteorological conditions • Reduced fuel consumption and operation costs • Reduced passenger delays

3.7 Real-time airport weather and status via data link	• Distribution of weather products to flight service stations
	• Improved access to information in the cockpit:
	  • via voice from flight service station,
	  • via data link (in line of sight) in text and/or graphical form
		• Improved flight planning through increased awareness of NAS status and associated restrictions
		• Allow pilots to avoid bad weather
		• Monitor changing weather conditions
		• Optimize surface operations

Table 3.2-2 -
Operational Improvements with Enabling Capabilities and Benefits - (Part 3)

Operational Improvement	Enabling Capability	Benefits
4.0 DEPARTURE ARRIVAL		
4.1 Enhanced decision support system to assist service providers in maintaining separation, assigning runways, and sequencing aircraft	• More accurate surveillance information via ADS-B	• Improved awareness of expected traffic • Reduced false and missing conflict alert and minimum safe altitude warnings
4.2 Navigation aids that allow RNAV-based and satellite-based departure and arrival routes, as well as precision approaches	• RNAV VFR/IFR routes, • arrival routes • GPS precision and non precision approaches	• Improved safety of flight • Improve terminal area efficiency and capacity • reduces delays, saving fuel and time

4.4 Improved terminal area weather information and cockpit displays	• Distribution of weather products to flight service stations
	• Improved access to information in the cockpit:
	  • via voice from flight service station,
	  • via data link (in line of sight) in text and/or graphical form
		• Allow pilots to:
		  • Avoid bad weather
		  • Monitor changing weather conditions
		• Optimize terminal operations
		• Parity of weather information for pilots and controllers allowing collaboration

4.5 Increased pilot situational awareness; decreased visual approach minima	• RNAV VFR/IFR routes • GPS IFR/VFR approaches • Cockpit display of traffic, terrain, obstruction, weather info.	• Increased airport access • Enhance safety
4.6 Increased ability to accommodate user-preferred arrival/departure routes, climb/descent profiles, runway assignments	• RNAV VFR/IFR routes • GPS precision and non-precision approaches • Navigation and obstruction information for pilot • Improved communication access • ADS-B/multilateration	• Improved user flexibility • Improve terminal area efficiency and capacity • Reduces delays saving time • Improve aircraft operational efficiency • Expanded surveillance coverage
4.8 Improved safety and runway utilization	• RNAV VFR/IFR routes • GPS visual approaches • Cockpit display of traffic, terrain, obstruction, weather information	• Reduce controlled flight into terrain • Reduce diversions to alternate destinations • Increase number of runway approaches, increasing overall airport capacity
4.9 Increased surveillance coverage	• Use of ADS-B, including multilateration, for surveillance	• Improve flexibility and efficiency in airspace use • Reduce separation in non-radar environment • Reduce fuel consumption • Reduces air and ground holding

Table 3.2-2
Operational Improvements with Enabling Capabilities and Benefits - (Part 4)

Operational Improvement	Enabling Capability	Benefits
5.0 EN ROUTE/CRUISE		
5.1 Reduction in en route delays	• Expanded surveillance coverage via ADS-B • Cockpit weather available • Access to SUA and NAS status information	• Savings in time and aircraft operating costs • Increased flexible use of airspace
5.2 Increased ability to accommodate user preferred trajectories, schedule, and flight sequence	• Increased decision support integration in oceanic/transition airspace • Controller Pilot Data Link Communications (CPDLC) • Expanded surveillance coverage via ADS-B	• Controller will have increased knowledge of projected traffic • Airlines will receive requested oceanic routes more frequently • Reduced communication workload and frequency congestion • Savings in time and aircraft operating costs
5.3 Improved airspace safety through increased air-ground surveillance coverage and air-air surveillance coverage	• Use of ADS-B for separation • Use ADS-B for cockpit display of traffic	• Reduced separation • Improved situational awareness

5.4 Enhanced hazardous weather avoidance	• Distribution of weather products to FSSs
	• Improved access to information in the cockpit:
	  • via voice from flight service station,
	  • via data link (in line of sight) in text and/or graphical form
		• Allow pilots to avoid bad weather
		• Monitor changing weather conditions
		• Parity of weather information for pilots and controllers collaboration

5.5 Increased pilot situational awareness	• Cockpit display of traffic, terrain, weather information	• Enhance flight efficiency and safety • Improved opportunities of separation assurance
5.9 Increased use of low-altitude direct routes using GPS navigation	• Cockpit display of traffic, terrain, weather information • Expanded surveillance coverage via ADS-B • WAAS	• Shortens flight route thereby reducing flight time, fuel utilization • Enhances safety through ability to avoid weather
5.11 Enhanced search and rescue operations	• Expanded surveillance coverage and enhanced situational awareness via ADS-B	• Decreased response time for rescue operations

Table 3.2-2
Operational Improvements with Enabling Capabilities and Benefits - (Part 5)

Operational Improvement	Enabling Capability	Benefits
6.0 OCEANIC		
6.1 Increased airspace capacity through reduced separation minima	• Surveillance coverage via ADS-A • Cockpit display of traffic via ADS-B • Enhanced oceanic probe	• Increased utilization of weather and fuel optimal routes • Increased access to airspace
6.2 Dynamic rerouting, step, climb, achieve, optimum altitude, cruise climb, fuel and time savings	• Enhanced oceanic probe • Increased decision support integration in oceanic/transition airspace • Surveillance coverage via ADS-A • Cockpit display of traffic via ADS-B	• Increase flight optimization, reducing flight time and operational expenses • Reduce maneuvering requirements via conflict detection
6.3 Dynamic management of route structures, more opportunity to obtain flexible tracks and user preferred profiles	• Enhanced oceanic probe • Increased decision support integration in oceanic/transition airspace • Surveillance coverage via ADS-A • Cockpit display of traffic via ADS-B	• Controllers will be better able to project the demand in transition airspace • Provides more accurate metering and spacing at the entrance to oceanic track system • Airlines will receive requested oceanic routes more frequently

3.3 Avionics for Flight 2000

The Flight 2000 avionics architecture supports a number of capabilities that are beneficial to a wide range of civil aviation users, ranging from low-end general aviation to air carrier aircraft. These capabilities are tied to delivery of the operational improvements identified in Table 3.2-1. For each user, one or more of the following capabilities will be installed as part of the Flight 2000 avionics suite:

- Area Navigation (RNAV) via GPS
- Terrain and Obstacle data base
- Cockpit Display of Traffic Information (CDTI) via ADS-B
- Textual and Graphic Weather Information
- Controller Pilot Data Link Communications (CPDLC)
- Digital data links (e.g., VDL Mode 2 or HF Data Link)

The evaluation will build on the existing capabilities of aircraft that are already equipped with FANS; however no new FANS installations will be funded under Flight 2000. For TCAS-II equipped aircraft, ADS-B and the CDTI capabilities will be added.

A number of opportunities also exist for military participation in Flight 2000. The FAA is working with the Department of Defense to help them equip aircraft operating out of Travis AFB in California. The Air Force's Global Access, Navigation, and Safety (GANS) program is a potential vehicle for collaboration. GANS is an umbrella avionics program that integrates GPS, navigation and safety equipment, the Joint Precision Approach and Landing System (JPALS), Navigation Warfare (NAVWAR), avionics modernization, military ground-based infrastructure, and Global Air Traffic Management (GATM).

3.4 Applicability to Free Flight and NAS Modernization

The operations concept and the Flight 2000 architecture lead to free flight and NAS modernization. Decision support systems and modern avionics in the cockpit are critical to full modernization. The Flight 2000 avionics initiatives are designed to accelerate benefits of satellite navigation, increased situational awareness, use of data link for weather and communications services, and adding safety functions in the cockpit to continue reducing the likelihood of accidents (e.g., the terrain data base to reduce controlled flight into terrain).

At Oakland Center controller/pilot data link communications will transition from the oceanic domain into en route transitional airspace, then into other en route sectors across the NAS. This transition will take advantage of FANS equipment on air carrier aircraft and allow for transition to the aeronautical telecommunications network (ATN).

The Flight 2000 evaluation of ADS-B will quantify the specific benefits that could be expected with improved surveillance, both air-to-air and air-to-ground. ADS-B is considered a critical enabling technology to reduce separation, increase flight flexibility, and realize the full benefits of

free flight. Based on early ADS-B performance measures, procedures can be developed for simulation and flight evaluation to refine changes in services for the entire NAS.

Not every free flight capability can or will be addressed within Flight 2000. The en route conflict probe, being developed at Indianapolis Center and Memphis Center will not be pursued in Flight 2000. Any addition of en route conflict probe capability will occur contiguous to those two centers, extending the benefit of a probe. Likewise, collaborative decision making (CDM) functionality being added between the FAA and the airline operations centers is well underway and is not a part of Flight 2000. One exception is the delivery to the cockpit of CDM products such as weather, the status of the NAS, Notices to Airmen, and the status of special use airspace.

One area of difference between Flight 2000 and the rest of the NAS is in the automation. Both Anchorage ARTCC (ZAN) and the Honolulu CERAP (ZHN) use the micro-EARTS. This system is different than the Host Computer or the Standard Terminal Automation Replacement System (STARS). By 2005, the Host will be replaced for en route and STARS will be completing delivery for terminal control. One area of risk is the difference in displays for the controllers. This automation difference is mitigated in Flight 2000 through use of the display system replacement (DSR) at Anchorage and Oakland ARTCCs.

In the Pacific oceanic airspace, the planning for Flight 2000 operational evaluation assumes that the reduced vertical separation minimums (RVSM) will be in place. However, this program is not currently financed. When RVSM in the Pacific is implemented it will allow for development of the replacement oceanic probe to use 1,000-foot separations. The realignment of certain transitional airspace from Los Angeles and Seattle Centers are also assumed to be completed, although Flight 2000 may need to support some procedural changes.

Operational improvements and capability demonstrations can be directly mapped to the recommendations of the RTCA Free Flight Task Force. The Final Report of RTCA Task Force 3, Free Flight Implementation, contains the full free flight recommendation description. Table 3.4 shows the relationship between the task force recommendations and the Flight 2000 architecture.

In Alaska, there is an immediate need to provide navigation routes at low altitude so that aircraft can travel between the villages below clouds (avoiding icing). Both VFR and IFR routes can provide this capability while avoiding terrain. Since much of the flying is below radar surveillance, it is advantageous to use RNAV routes on separate flight paths into and out of these villages. This will increase airspace access and operational flexibility within these areas.

Table 3.4-1 - Operational Improvements Mapped to Free Flight Recommendations

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
1. RNAV Procedures	RNAV procedures for a minimum of 49 airport in Alaska and each airport in Hawaii
2. Quickly develop standards, criteria, procedures, and training for use of area navigation capabilities	RNAV VFR and IFR routes, FMS approaches in Alaska and Hawaii
3. RNAV routes below FL 180	Providing an off-airway capability that provides terrain clearance through a combination of GPS and a terrain data base, eliminating the need for Victor Airway structure
4. Expand National Route Program	Not in Flight 2000
5. Decrease the 200 nm radius restriction for NRP filing	Increased use of RNAV arrival and departure paths to join free flight airspace
6. Develop mechanisms to provide pre-departure feedback to flight planners	Not in Flight 2000
7. Implement rationing-by-schedule during Ground Delay Programs	Not in Flight 2000
8. Establish more flexible ground delay program	Not in Flight 2000
9. Establish coordinated effort to define information on special use airspace (SUA)	Complete prior to Flight 2000
10. Improve information exchange on SUA status	SUA status will be uplinked directly to aircraft in Alaska and Hawaii
11. Develop and implement real time SUA notification	Will be a service in Flight 2000
12. Streamline the FAA certification process	Major thrust of Flight 2000 is streamlining of avionics certification and approval for operational use.
13a. In collaboration with the users, the FAA should make a decision on the initial air/ground data link for domestic ATC	Develops and deploys flight information services and provides for FANS CPDLC transition from the oceanic to domestic en route airspace
13b. The FAA should collaborate with users in the continuing development of oceanic data link	HF data link, the use of SATCOM, and expanding the functionality of FANS equipage is planned for the airspace controlled by Alaska and Oakland
14. Improve telecommunications to enhance flow of information for traffic flow management	Not part of Flight 2000

Table 3.4-1 - Operational Improvements Mapped to Free Flight Recommendations (Continued)

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
15. Incorporate airline schedule updates in FAA decision support systems	Not part of Flight 2000
16. Enhance or replace the current ATM monitor alert function	Not part of Flight 2000
Expedite deployment of D-ATIS and PDC	D-ATIS to be added as part of FIS functionality in Anchorage and Honolulu
18. Initiate standards for cockpit display of traffic information	CDTI is part of the core set of avionics for evaluation
19. Deploy a ground-based conflict probe	Replacing oceanic conflict probe but domestic en route probe is not part of Flight 2000
20a. Expedite technologies for improved transition to and from terminal airspace	CTAS deployment will continue independent of Flight 2000
20b. Move mature elements of CTAS forward into implementation	CTAS deployment will continue independent of Flight 2000
21. Investigate feasibility of using WAAS for vertical guidance in RVSM	Not part of Flight 2000
22. The FAA should support down-link of real-time aircraft-reported weather	As part of avionics Upgrade 1, aircraft may provide electronic PIREPs with temperature, humidity, and winds for use in icing predictions
23a. Develop more accurate forecasts of convective activity	Not part of Flight 2000
23b. Work with the user community to achieve consensus and timing for ADS-B technology	Major emphasis area of Flight 2000, including assessment or alternatives and transition strategies
24. Develop methodology and tools to measure and predict dynamic density	Not part of Flight 2000
25. Collaborative exchange of planning information	FAA to AOC collaboration not part of Flight 2000; however, up-link of NOTAMs, SUA status, and weather via data link are part of collaboration with the cockpit
25a. FAA and users must determine the details of improved user-TFM interaction	Not part of Flight 2000
25b. Develop programs and flexible procedures to exchange real-time information with shift toward controlled time of arrival	Not part of Flight 2000

Table 3.4-1 - Operational Improvements Mapped to Free Flight Recommendations (Continued)

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
26. Establish procedures for aircraft-to-aircraft separation.	Uses CDTI and evaluation of ADS-B with specific experiments supporting self-separation capabilities.
27. Implement precision missed approaches and precision simultaneous approaches and departures.	Flight 2000 will use precision missed approaches and departures with additional testing on applicability of ADS-B for independent arrival streams to closely spaced runways (testing at an existing PRM location following full human-in -the-loop simulation).
28. Investigate increasing runway acceptance by permitting two aircraft to occupy the runway at the same time.	Not part of Flight 2000
29. Expand NRP below FL 290.	Not part of Flight 2000
30. Issued Advance Notice of Proposed Rulemaking to implement domestic RVSM above FL290	Not part of Flight 2000
31. Determine requirements for reduced horizontal separation standards, including surveillance performance	Performance of ADS-B will be measured, both air-to-air and air-to-ground and applied to horizontal separation as appropriate
32. Rulemaking to remove the 250 knot restriction below 10,000 feet	Not part of Flight 2000
33. Determine human perception of separation time and distance buffers	Performance of ADS-B will affect potential changes in separation and both pilot and controller acceptance of surveillance information will be evaluated
34. Human-in-the-loop simulations of dynamic resectorization	Not part of Flight 2000
35. Reemphasize the role of the Airport Improvement Program in increasing airport capacity	Not part of Flight 2000
MT1. Increase FAA ARTCC decision support capabilities to include the total US navigation data base	Not part of Flight 2000
MT2. Accelerate and expand programs to support GPS/WAAS as a primary navigation system	Develops procedures and provides avionics that promote transition to satellite-based navigation
MT3. Ensure that STARS and DSR have the "hooks" to accommodate ADS-B	Develops surveillance server, displays ADS-B on DSR

Table 3.4-1 - Operational Improvements Mapped to Free Flight Recommendations - (Continued)

Free Flight Task Force Recommendation	Fllight 2000 Enabling Capabilitiy
MT4 Develop and implement weather and flight information into the cockpit	Provides on opening day weather, NOTAMS, SUA status via data link to aircraft equipped withthe core system plus Upgade 1
MT5 Develop and deploy dynamic sectorization	Not a part of Flight 2000
MT6 Develop and deploy ADS in non radar areas to support user-preferred trajectories	Flight 2000 relies on ADS-A in the oceanic and ADS-B in domestic airspace to improve surveillance in non radar areas, including the potential use of air-air applications of ADS-B to achieve user-preferred trajectories
FT1 Expand the number of airports to receive surface surveillance capability	Adds ADS-B at 11 airports after demonstratiopn at Anchorage and Bethel
FT2 Define surveillance architecture and infrastructure for both terminal and en route airspace incorporating both dependent independent surveillance elements	Performance and integration of ADS-B into the NAS is a critical element of Flight 2000 and will lead to refinement of the surveillance architecture for the NAS
FT3 Determine LAAS capability and implement LAAS	Flight 2000 will install LAAS at Anchorage, Juneau and Honolulu as operational systems and may require additional units supporting other airports

3.5 Planned NAS Improvements and Flight 2000

The capital investment program (CIP) funded by the Facilities and Equipment Appropriation is not adversely affected by Flight 2000. The CIP will provide improvements towards the operations concept independent of Flight 2000. The tables in Appendix C have been organized to show the operational improvements under development in parallel with the Flight 2000 effort. They are organized consistent with the NAS 2005 Operational Concept.

3.6 Flight 2000 Capabilities by Location

3.6.1 Alaska Site Capabilities

The Anchorage ARTCC will act as one of the primary centers of activity for Flight 2000. It will be the communications clearing house for separation and flight information services for the majority of Alaska airspace. The Anchorage airport and terminal airspace represents the starting point for most operational evaluations. For example, it is in the terminal airspace and on the airport surface that the performance of ADS-B will be evaluated before being deployed at other airport locations for surface and terminal surveillance. It will be in the en route environment with radar coverage that ADS-B will be examined for application in the en route airspace. Plans call for rolling out ADS-B capabilities prior to September 2000 at Anchorage, then moving to other locations. Two types of ADS-B functionality are planned. For surface and terminal, some locations will use only ADS-B, while others will also have multilateration capability (time of arrival of position reports). The decision on the proper mix of capabilities will occur following initial validation at Anchorage.

Bethel, Dillingham, and Nome represent candidates for use of ADS-B with multilateration to provide surface and terminal airspace advisories and improved situational awareness. A unique radar screening situation which limits surveillance coverage between Cold Bay and Dutch Harbor can be improved by placing ADS-B ground systems at Dutch Harbor and linking back to Anchorage ARTCC. Juneau will also take advantage of improved surveillance provided by ADS-B.

Communications in Alaska is a mix of land lines and the satellite-based Alaskan national airspace system interfacility communications system (ANICS) which connects FAA facilities. The ANICS forms the backbone for communications and routing of information both for towers, flight service stations, and uplink of information to the cockpit from these facilities.

3.6.2 Hawaii Site Capabilities

In Hawaii, the focus is on intercity travel and improvement in services to the pilot. As in Alaska, the key locations are the major air travel points and selected additional surveillance coverage with ADS-B. The center of Flight 2000 activity will be at the Honolulu CERAP's new location adjacent to the Honolulu TRACON.

The remote ADS-B sites are designed to provide surveillance for gaps in radar coverage. In addition, two en route surveillance sites, Haleakala on Maui and Pahoa on Hawaii may be upgraded to Mode S sites to facilitate traffic information services and replace older equipment. ADS-B sites will be added in Hawaii as radar coverage gap fillers. This capability will include an ADS-B ground receiver and may rely on multilateration as an independent means of verifying position.

3.6.3 Oakland Airspace

At the Oakland ARTCC the emphasis will be on oceanic airspace and the transition to domestic airspace. The Flight 2000 effort will capitalize on existing FANS equipped aircraft to evaluate data link services, and investigate interoperability and transition issues.

Additional DSS are needed, including replacement of the oceanic conflict probe that will accommodate RVSM and user-preferred routings. Greater emphasis on use of ADS-A will improve maneuvering. Flexibility will increase in transitional airspace under the control of Oakland during Flight 2000. This includes airspace from Seattle and Los Angeles Centers.

3.6.4 Other Locations

Depending on experimental design and the need for ground instrumentation, some additional test sites may be needed. For example, the communications test bed being used at the FAATC will likely be used to measure throughput and performance of communications systems prior to deployment in Flight 2000 or during testing under Flight 2000. Certain NASA and DoD facilities may also be needed. Until operational test and evaluation plans are finalized, the option to select additional sites will remain open.

3.6.5 Summary of Capabilities by Location

Tables 3.6-1 and 3.6-2 provide a summary view of the planned Flight 2000 capabilities by location.

Table 3.6-1.
Flight 2000 Capabilities By Location

Site Capabilities	GPS Approaches	Proc Dep & Arr	GPS IFR/VFR Routes	LAAS	ADS-B	Multilateration	ASDE/AMASS/ADS-B	Terminal/Surface Traffic Advisory Display	Surveillance Server	TIS via 1030 MHz	FIS Processor Server	FIS (VHF Data Link) Wx, SUA, NOTAMS	A/G Satcom	Mode S Beacon	D-ATIS
Anchorage ARTCC					✓			✓	✓	✓	✓	✓	✓		
Anchorage TRACON								✓						✓	✓
Anchorage Int'l Airport/Tower	✓	✓	✓	✓	✓	✓	✓		✓						
Kenai AFSS												✓	✓		
Bethel Airport/Tower	✓	✓	✓	✓	✓	✓		✓		✓		✓			
Nome Airport (FSS)	✓	✓	✓		✓			✓				✓			
Dillingham Airport (FSS)	✓	✓	✓		✓			✓				✓			
Juneau Airport/Tower	✓	✓	✓	✓	✓			✓							
Juneau AFSS								✓				✓			
Villages	✓	✓	✓												
Cold Bay Airport (FSS)	✓	✓	✓					✓				✓			
Dutch Harbor Airport	✓	✓	✓		✓	✓									
Other Radar Gap Fillers (AK/HI)					✓										
Honolulu CERAP					✓			✓	✓	✓	✓	✓			
Honolulu TRACON								✓							✓
Honolulu Int'l Tower	✓	✓	✓	✓	✓	✓		✓							
Honolulu AFSS															
Lihue Airport/Tower	✓	✓	✓	✓	✓			✓				✓			
Hoolehea Airport/Tower	✓	✓	✓	✓	✓			✓				✓			
Kailua-Kona Airport/Tower	✓	✓	✓	✓	✓			✓				✓			
Hilo Airport/Tower	✓	✓	✓	✓	✓			✓				✓			
Kahului Airport/Tower	✓	✓	✓	✓	✓			✓				✓			
Mt. Haleakala										✓				✓	
Pahoa										✓				✓	

Table 3.6-2.
Oceanic/Transition Airspace Site Capabilities

	ADS-A	Oceanic Conflict Probe	Oceanic Data Link CPDLC	HF Data Link	Domestic CPDLC
Anchorage ARTCC	✓		✓	✓	✓
Oakland ARTCC	✓	✓	✓	✓	✓

3.7 <u>Summary of Enabling Technology and Procedures</u>

Appendix C summarizes technology and procedures required to implement the operational improvements identified in Chapter 2. The improvement is also characterized by safety (Saf.), efficiency (Eff.), capacity (Cap.), and economic (Eco.) return to the FAA and/or users. The enabling procedures identify areas where procedural changes are needed. The recommended avionics are identified in paragraph 3.3.

3.8 <u>Flight 2000 Summary of Operational Evaluation Tasks</u>

Flight 2000 provides the opportunity to operationally evaluate procedural changes that can benefit the NAS by providing safety, capacity, and efficiency benefits to a wide segment of NAS users. The capabilities planned for Flight 2000 provide the opportunities to modify procedures. In order to develop these modifications, research must be conducted, data gathered for safety assessments, methods developed for modifying procedures, and implementation strategies defined. This section provides an overview of the operational evaluations that need to be performed during the Flight 2000 demonstration/evaluation. It is not an all-inclusive list. Each project will need to develop a full operational test and evaluation plan, with some of the evaluations being conducted prior to avionics certification and the delivery of initial services. User participation in developing these operational evaluations will be essential.

3.8.1 Communications

The Flight 2000 operational concept proposes new ATC services that will require various data link solutions. These services include new forms of navigation including GPS, WAAS and LAAS, new surveillance solutions such as ADS-A and ADS-B, new controller to pilot communications (CPDLC), request reply services for weather, SUA status and NOTAMS, and broadcast weather. To support the requirements imposed by these new services both addressed and broadcast data links are required. Table 3.8.1 provides a summary of the new FAA data link services and the potential communications links.

Table 3.8.1
Data Link Services and Proposed Communications Links

Flight 2000 Data Link Service	Potential Communication Link
Request/Reply Weather text and graphics	VDL Mode 2
Request/Reply Special Use Airspace (SUA) status	VDL Mode 2
Request/Reply Notice to Airmen (NOTAMS)	VDL Mode 2
CPDLC	VDL Mode 2 ACARS Sat Com HF
ADS-A	VDL Mode 2 ACARS Sat Com HF
ADS-B, TIS	Mode-S L-Band (1090) UAT L-Band (960) VHF - STDMA (Mode 4)
Broadcast Weather	VDL Mode 2 VHF - STDMA (Mode 4) Other VHF
GPS	L-Band
Wide Area Augmentation System	L-Band
LAAS	VHF - STDMA (Mode 4) Other VHF

The Flight 2000 communications architecture will take advantage of existing standards and infrastructure to the extent practical, while providing a path to the future NAS. Based on that approach, Flight 2000 plans to utilize the proposed VDL Mode 2 system in Alaska and Hawaii.

VDL Mode 2 will be used as a primary candidate for addressed data links . Both the protocols and standards are mature and availability of the system is expected to be good at FLIGHT 2000 sites.

The FAA plans to use existing GPS technology for navigation services. However, for many navigation requirements GPS requires augmentation to provide adequate precision. Both WAAS and LAAS are being pursued for Flight 2000 to support the precision navigation requirements. WAAS will provide the wide area augmentation over L-Band and LAAS will use VHF to broadcast the LAAS correction.

Both ADS-B and weather services require a broadcast solution. For ADS-B, the FAA plans to use 1090 mhz extended squitter. In addition to 1090, the FAA plans to evaluate other ADS-B solutions. The major candidates are the UAT system which is presently implemented at 960 mhz, and the STDMA system that operates over VHF. Both of these ADS-B alternatives provide broadcast weather and LAAS solutions that may be used where these systems are installed. In general, the FAA plans to use VDL Mode 2 to provide broadcast weather. However, standards and protocols must be developed and implemented as part of the Flight 2000 activities.

3.8.2 Navigation

Flight 2000 will accelerate the implementation of GPS-based procedures beyond just providing approach and landing capabilities. Precision missed approach procedures can reduce approach minima. Precision departure guidance can provide noise reduction benefits. Use of VFR and IFR GPS navigation routes (RNAV) can support both improved direct navigation and separation in airspace where airways do not exist. The differential correction capabilities of the wide area augmentation system (WAAS) and local area augmentation system (LAAS) can be installed and integrated into the avionics. With increased reliance on waypoints and satellite navigation, avionics carry navigation databases that require periodic update of changes. All of these activities focus on providing increased airspace access.

Both Alaska and Hawaii have a significant number of FAR Part 91 and 135 operators who fly at low altitude to avoid weather. In Alaska, the hub and spoke operations supporting the many villages allow RNAV routes to be used for safe separation (inbound and outbound routes) of visual and instrument traffic. The concern with much of this flying is that the cardinal altitudes are frequently not used. With the precision of GPS, there is a potential of increased collision risk if aircraft are flying in opposite directions on the same route at the same altitude. While these routes run counter to the concepts of free maneuvering in a free flight concept, they will provide a transition capability that addresses an immediate safety concerns of controlled flight into terrain and mid-air collisions. Table 3.8.2 relates the navigation tasks to the desired operational improvements.

Table 3.8.2.
Summary of Navigation Evaluation Tasks

Operational Improvement	Enabling Capabilities	Operational Evaluation
• Increase the number of airport runways that have instrument precision and non precision approaches	• Provide GPS approach capabilities at airports involved in Flight 2000	• Assess human factors of approach design • Assess human factors of avionics operations • Track use and benefit of additional approaches
• Provide RNAV VFR approaches	• Significant operations in Alaska are conducted under Special VFR. Use RNAV VFR approaches to provide visual flight paths for these operations	• Assess pilot acceptance to use of approaches
• Establish IFR/VFR departure and arrival routes to improve airport throughput	• Supplement existing SIDs and STARs and add new routes with procedures that transition from en route airspace assuming free flight	• Evaluate procedural methods to transition from free flight to airport arrivals and approaches • Evaluate transition from the airport into free flight • Evaluate arrival paths that offer efficiencies to equipped aircraft
• Develop precision missed approaches for GPS approaches where approach minima can be reduced	• Use the precision path guidance that differential GPS can provide to design missed approach procedures that produce lower landing minima in mountainous locations	• Evaluate alternative and benefits of required navigation performance
• Provide precision departures as a noise mitigation measure	• Use the precision path guidance that differential GPS can provide to design precision departures to reduce the noise footprint on departure	• Use existing airport noise monitoring to measure improvements • Measure flight track conformance on ADS-B equipped aircraft and radar flight track data on nonequipped aircraft
• Establish GPS direct routes between Alaska hubs and villages to improve navigation and safety	• Lay out routes defined by waypoints • which provide direct routing navigation with inbound and outbound separation for low altitude operations	• Safety assessment • Pilot acceptance and use
• Provide differential GPS corrections	• Install LAAS	• Monitor performance
• Terrain map for avoiding controlled flight into terrain	• Provide terrain and obstruction data base in core set of avionics	• Human factors analysis of presentation of information • Define advisory function performance
• Electronic update of avionics data bases for navigation, terrain, and obstructions	• Investigate means for pilots to update avionics data bases through electronic transfer	• Evaluate data integrity, transmission, update, verification and validation needs

3.8.3 Surveillance

Flight 2000 provides the opportunity to demonstrate and evaluate the operational improvements possible with ADS-B. The operational concept linked to ADS-B is to provide an alternative means of surveillance, other than primary radar and beacon technology. While not all of the possible improvements will be realized during Flight 2000, sufficient numbers of aircraft will be equipped to thoroughly test ADS-B applications. These operational evaluations will help structure the transition of ADS-B to the contiguous 48 states. Capabilities identified for ADS-B by the Free Flight Task Force to improve existing surveillance, accelerate implementation of free flight, improve efficiency and flexibility, and possibly allow reduced separation distances in the NAS. Each must be demonstrated and evaluated. Transition issues for modernizing surveillance and separation procedures in the NAS will be identified. Performance data will be collected on ADS-B as a surveillance tool in comparison with radar and beacon surveillance performance.

Within the cockpit, ADS-B supports cockpit display of traffic information (CDTI). Operational evaluation of this capability will define the necessary procedures to go beyond providing an advisory function of improved situational awareness. In the full implementation of CDTI, procedures could be developed which would allow CDTI to be used for separation of aircraft; climb, descent, and passing maneuvers; and as an integral part of IFR operations to closely spaced parallel runways.

Since 1992, the FAA has been conducting research on the use of ADS-B for surface surveillance. Numerous demonstrations have shown that tracking of aircraft and ground vehicles can be significantly improved by use of differentially corrected GPS. Flight 2000 provides the opportunity to integrate surface movement surveillance capabilities with planned safety systems and extend the coverage into the terminal airspace, making a truly seamless surveillance system. Recent work at Atlanta has demonstrated the utility of adding multilateration to ADS-B capabilities on the ground and in terminal airspace. Multilateration uses receiving stations around the airport to measure time of arrival of either a transponder reply or an ADS-B report to determine aircraft position. Multilateration provides independent ground confirmation of aircraft position, with or without the GPS position report from ADS-B.

The FANS aircraft operating over the ocean have a capability called ADS-A, or addressable automatic dependent surveillance. Here the controller requests a position report that is then automatically provided by the avionics. ADS-A is currently underutilized in managing separation. The FAA has the ability to evaluate how changes in update rates can effect decisions on granting more flexibility in use of airspace outside of normal surveillance coverage.

Within oceanic airspace, pilots are allowed to use TCAS to maneuver around other aircraft. ADS-B will extend the range for similar air-to-air maneuvers. Table 3.8.3 relates the surveillance tasks to the desired operational improvements.

Table 3.8.3.
Summary of Surveillance Evaluation Tasks

Operational Improvement	Enabling Capabilities	Operational Evaluation
Extend surveillance coverage in en route and terminal airspace	Deploy ADS-B with multilateration as coverage gap filler	• Demonstrate performance of ADS-B and multilateration • Verify suitability for separation services • Develop procedures for use in separation and test procedures
Surveillance fusion for automation to improve separation assurance functions and present information to controllers	Use surveillance fusion capability for ASDE/AMSSS and develop a fusion capability for use in u-EARTS Determine approach for host replacement for en route	• Development and Test at FAA Technical Center for both u-EARTS • Field test at Anchorage • Test host replacement integration of ADS-B at FAA Technical Center
Provide surface surveillance	Integrate ADS-B plus multilateration with ASDE/AMASS at ANC and ADS-B plus multilateration at other airport locations	• Measure performance, with and without LAAS • Evaluate tower controller acceptance of display and presentation of information • Evaluate procedures for use of ADS-B at Alaska and Hawaii locations • Document improvements over current nonradar Special VFR and IFR procedures
Airborne conflict avoidance	ADS-B with CDTI	• Develop and assess procedures • Conduct human factors evaluations on CDTI • Full fidelity human-in-the-loop simulations • Collect benefits information
Enroute maneuvering to pass aircraft and climb/descent	ADS-B with CDTI	• Same as Airborne Conflict Avoidance
ADS-B based separation standards	ADS-B with CDTI	• Same as Airborne Conflict Avoidance
Precision runway monitoring for simultaneous independent arrival streams to parallel runways	ADS-B with CDTI plus final approach monitoring aid and LAAS or WAAS	• Flight test at appropriate location with existing PRM • Flight test at PRM site with reduced spacing
Oceanic maneuvering Air-Air with ADS-B Air-Ground with ADS-A	ADS-B with CDTI in cockpit with Oceanic automation to accept ADS-A updates	• Same as Airborne Conflict Avoidance • Test variable update rates of • ADS-A to support procedural maneuvering
Cockpit display of traffic information	Design MASPS/MOPS	• Same as Airborne Conflict Avoidance
CDTI assisted approaches in terminal airspace (enhanced visual acquisition of lead aircarft, stationkeeping)	ADS-B with CDTI	• Same as Airborne conflict Avoidance

3.8.4 Decision Support

Within the ground automation capabilities, performance testing is necessary to determine specific requirements for movement of information between facilities and systems, integration of information for presentation to the controller, and testing controller acceptance of the decision support aids. The specific testing required needs to be defined. Critical issues center on human factors and workload. Several key capabilities require integration and procedure development. In oceanic work at Oakland, the ground portions of data link integration into existing systems and DSR are needed. Full testing of an oceanic probe will be required

3.8.5 Modeling and Simulation

There will be extensive use of modeling and simulation relating to performance and human factors issues on design of avionics and presentation of information. Flight procedural changes will also require modeling for refinement of the operational concepts and benefits analyses. The use of simulation for procedural development will be conducted at the FAA Technical Center. Detailed modeling and simulation requirements are being developed, and will be available as part of the detailed Flight 2000 plans.

3.9 Alaskan Operation Systems

Table 3.9-1 details how the quantities of air traffic control facilities in Alaska compare with the contiguous 48 totals:

Table 3.9-1

Alaskan Air Traffic Control Facilities

	Total U.S.	Alaska
Airports	18,292	1,100
Public Use Airports	5,389	287
Commercial Service Airports	671	80
Control Towers	476	13
Terminal Radar Control Facilities	177	2
En route Control Facilities	21	1
Flight Service Stations	94	17

3.9.1 Communications - present and future

This section describes the various communications in Alaska and their use. It is organized into sections on present and future systems and in sub-categories of air-to-air, air-to-ground, and ground-ground. These are traditional categories of communications used in FAA.

3.9.1.1 Present Communications

The vast distances and harsh environmental conditions of Alaska pose special problems for communications systems. The communications systems developed and effectively used in the "contiguous 48" are often not suitable in Alaska. The Alaska Region has responded to these challenges by developing innovative solutions adapted to Alaskan conditions.

Air-Air

Aircraft can communicate via certified avionics in the HF, VHF, UHF spectrums. For data link communications, the only system currently sending signals between aircraft is TCAS. TCAS is considered a surveillance system rather than a communications system and will not be addressed in this section.

Air-Ground

Air traffic communications are primarily voice. Alaska contains all four levels of ATC facility (Oceanic, En Route, Terminal, and Flight Service Station) and correspondingly uses voice facilities for each. Oceanic regions require HF voice service due to the long distances involved. Aircraft in the Oceanic regions supported from Anchorage communicate via CPDLC by satellite or by HF radio to ARINC stations in Honolulu. ARINC transcribes the HF messages into data messages and sends them to Anchorage via ground-ground communications circuits. Oceanic controllers send messages to aircraft via the reverse path. Oceanic control also uses VHF communications when aircraft are within range of one of the VHF stations.

En Route voice communications are serviced by 58 RCAG sites distributed throughout Alaska and linked to Anchorage ARTCC via ground-ground circuits.

Three Automated Flight Service Stations (AFSS) are located in Kenai, Fairbanks and Juneau. These AFSS's and 14 Flight Service Stations utilize 180 remote communication outlets (RCOs) for voice communications.

Each controlled airport with a manned tower uses remote transmitter/receiver (RTR) voice communications. Satellite voice communications are currently limited to emergency calls by aircraft with passenger voice systems as a backup to operational air traffic control systems.

Some data link services are in existence in Alaska. ACARS provides AOC service via 14 stations including some stations located in Canada with coverage into Alaskan airspace. Although used for some non-time critical ATC applications including PDC, and D-ATIS. ACARS is limited in capacity and a higher capacity system is needed for long term ATC requirements. FANS service is available using either ACARS stations or satellite as the transmission link.

Ground-Ground

Ground-Ground communications began as telephone circuits and has grown to include a wide array of media. Alaskan geography makes conventional telephone media such as cable, microwave, and fiber optic expensive and prone to service outages and degradation. In recent years the Alaskan Region has deployed ANICS (Alaskan National Airspace System Inter-facility Communications System) to provide a state-wide, high availability, ground-ground connectivity. ANICS provides a satellite-based, two way transmission path between remote sites and FAA air traffic control sites. Figure 3.9-1 depicts the ANICS architecture. To date 34 critical sites have been installed to carry air-ground voice

and surveillance data. Standard leased telephone cable and microwave links are used as locally available.

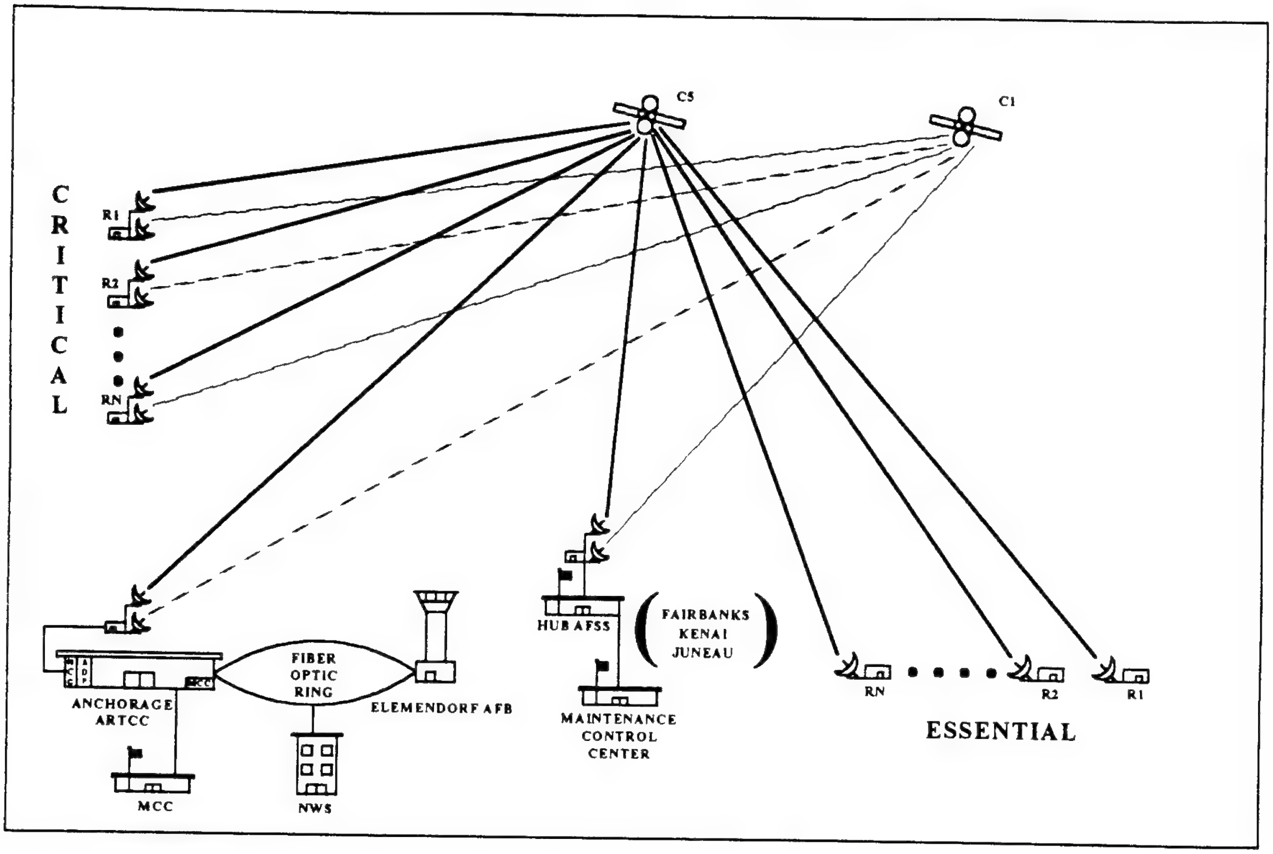


Figure 3.9-1

ANICS Overall System Architecture

Voice and data communications flow over the circuits provided by ANICS and the other media discussed above. Voice circuits terminate at the remote radio sites (RCAG, RCO, and RTR) and at the voice switches in ATC facilities. FAA uses NADIN (National Airspace Data Interchange Network) which is composed of two interconnected data systems, NADIN I and II to distribute data. NADIN I is a message switching system and NADIN II is a packet switching system. NADIN I is an older system and is proposed to be phased out now that NADIN II is deployed. NADIN is used to pass a variety of data such as flight plans and weather data. Radar data is typically not carried over NADIN and is instead transmitted over dedicated circuits (radar data is carried over ANICS in Alaska). Anchorage is the only location with NADIN connections today and is primarily used for passing data back to the rest of the NAS.

Airports and terminal control facilities usually have dedicated local telephone lines and buried cable to connect all of the ATC related communications on an airport and is generically referred to as Airport Cable Loop.

3.9.1.2. Future Communications

For Flight 2000, existing communications systems will be largely untouched in order to provide continuity of service and low risk to ATC operations. All of the "present communications" described above are assumed to continue. This section will only discuss supplemental systems to support Flight 2000 and potential new services to be demonstrated and evaluated in Flight 2000.

Air-Air

A number of operational improvements targeted for Flight 2000 build on direct communications between aircraft, rather than relying on air-ground communications. Many of the operational improvements associated with Free Flight build on the use of Automatic Dependent Surveillance Broadcast (ADS-B), which uses aircraft-to-aircraft data communications to fulfill surveillance needs not currently met by today's systems. Unlike Addressed ADS (ADS-A), which operates only in an air-ground mode, ADS-B data is available to all users within reception range of the transmitting aircraft. ADS-B regularly reports an aircraft state vector that includes 3-dimensional position data and velocity (speed and heading). The potential for widespread, inexpensive distribution of ADS-B data is made possible with the broad user acceptance of GPS, which can allow most users to have accurate navigation data at a relatively low cost in comparison to other means of accurate navigation.

For the Flight 2000 project, ADS-B data will be transmitted via the 1090 long squitter enhancement to Mode S transponders. In addition, other potential technologies supporting ADS-B (such as UAT or STDMA) will be evaluated as Phase III capabilities.

Other air-air communications have been proposed to facilitate the coordination of maneuvers between aircraft, either in-flight or on the surface. Some air-air communications may be addressed as Phase III capabilities, but will not be part of the baseline avionics suite, as outlined in paragraph 3.3.

Air-Ground

The primary issue for air-to-ground communications systems is the development of data link(s). As previously mentioned, ACARS is an existing system with limited capacity. Several new systems have been proposed including VHF Data Link Mode 2 (VDL2) and VHF Data Link Mode 3 (VDL3). VDL Model 2, a data only system, will be used for Flight 2000. VDL2 ground stations are being developed and will be deployed for use in Flight 2000.

Weather information (graphical and text) and digital automatic terminal information service (D-ATIS) may be provided using VDL2.

Mode S has also been considered a data link candidate, especially for transmission of Traffic Information Service (TIS). The functionality of Mode S is limited by its primary surveillance function and its rotating antenna structure.

Ground-Ground

Ground-ground communications will be required to support the data link transmission as well as communications of other Flight 2000 systems. ANICS is the primary candidate for transmission in Alaska and it has unused capacity to support Flight 2000. VDL2 ground stations can be located at ANICS sites to support Flight 2000 operations or connected to ANICS by local cable or telephone circuits to meet siting requirements.

3.9.2 Navigation

Alaska has 43 VOR sites and numberous NDBs scattered across the state. There are no plans to expand any VOR, ILS, or MLS facilities for Flight 2000.

To more effectively use GPS as a navigation aid, Wide Area Augmentation System (WAAS) reference stations are expected to be installed at a minimum of 3 sites in Alaska. These WAAS sites will enable more accurate en route and terminal navigation and approaches down to Category I minimums. Local Area Augmentation System (LAAS) sites are expected to be installed at Anchorage, Bethel, and Juneau. These LAAS sites will provide correction data to ensure accurate navigation within a 30 mile radius for Category I, II, and III approaches.

3.9.3 Surveillance

No new radar systems are proposed for Flight 2000. Several ADS-B candidate sites are Anchorage, Juneau, Bethel, Dillingham, Cold Bay, Dutch Harbor, Fairbanks, and Nome. Additional sites may be added as technologies are proven.

The table below details the radar surveillance sites currently in place in Alaska.

Table 3.9-1.

Current Radar Sites in Alaska

	ID	Site	Surface Radar	Terminal Radar	En Route Radar
1.	ANC	Anchorage	ASDE-3	ASR-8/BI-5	
2.	BKA	Biorka Island			BOS/BI-5
3.	SCC	Dead Horse			BOS/BI-5
4.	FAI	Fairbanks		ASR-8/BI-5	
5.	ENA	Kenai			ARSR-3/BI-5
6.	MDO	Middleton Island			BOS/BI-5
7.	SNP	St. Paul Island			BOS/BI-5
8.	BRW	Barrow			FPS-117
9.	SYA	Shemya			BOS/BI-5
10	MPY	Murphy Dome			FPS-117
11	AKN	King Salmon			FPS-117
12	EHM	Cape Newenham			FPS-117
13	YCU	Cumshewa			FPS-117
14	TLJ	Tatalina			FPS-117
15	OTZ	Kotzebu			FPS-117
16	CZF	Cape Romanzof			FPS-117
17	CDB	Cold Bay			FPS-117
18	FYU	Fort Yukon			FPS-117
19	TNC	Tin City			FPS-117

3.9.4 Automation

Automation needs within the Alaskan region are satisfied by several systems:

(a) the Model 1 Full Capacity (M1FC) system for the three Automated Flight Service Stations (AFSS)

(b) the Alaska Aviation Weather Briefing System (AAWBS) for graphic weather needs at the AFSSs and 14 Flight Service Stations (FSS),

(c) the ARTS-2a systems for radar data processing at the Anchorage and Fairbanks TRACONS (to be upgraded to ARTS-2e systems in March '98),

(d) dual EARTS systems at the Anchorage ARTCC for radar data processing (being replaced by the Micro-EARTS system, presently in Operational Readiness Demonstration), and

(e) flight data processing provided for the Anchorage ARTCC, Anchorage and Fairbanks TRACONS, Anchorage, Fairbanks, King Salmon, Kodiak, Juneau, Bethel, Merrill, Kenai, Elmendorf AFB, and Eielson AFB ATCTs by the offshore computer system (OCS). The Anchorage ARTCC radar data processors are capable of simultaneously handling long range/short range data strings, primary/secondary digital data, ASR/ARSR/FPS-117/RAMP radars inclusive. Merged radar and ADS position data display capability exists in an R&D capacity.

In September, 1997 new display system replacement (DSR) equipment will be received in the ARTCC to populate a new operations room. It is anticipated that the Air Traffic operation will migrate to and be operational in the new area by May, 1998. Additional ARTCC systems include the Dynamic Ocean Tracking System (DOTS), the Enhanced Traffic Management System (ETMS) and the ATC Interfacility Data Communications System (AIDC). Planned ARTCC operations support systems include the Weather and Radar Processing system (WARP) and the Special Use Airspace Management System (SAMS). Additionally, both the terminal and en route arenas are served by the Systems Atlanta Information Display System (SAIDS - IDS-4). Finally, the OASIS system is scheduled to replace the MIFC systems within the AFSS/FSS Facilities beginning in FY98 and will be available for support to Flight 2000.

3.9.5 Facilities

The Alaska region supports an ARTCC at Anchorage, TRACONs at Anchorage and Fairbanks, ATCTs at Anchorage, Fairbanks, Juneau, Kenai, Bethel, King Salmon, Kodiak, and Merrill Field. There are Automated Flight Service Stations at Fairbanks, Juneau, and Kenai. Flight Service Stations have been retained at Dead Horse, Kotzebue, Nome, Dillingham, Iliamna, McGrath, Barrow, Cold Bay, Homer, Talkeetna, Palmer, Northway, Sitka, and Ketchikan. The NAS infrastructure which supports these facilities includes the Alaska NAS Interfacility Communications System (ANICS) and leased satellite, fiber, and micro-wave communications systems. Due to unreliable commercial power availability and the remoteness of most locations, all ATC and NAS resources in Alaska are equipped with standby power generating capability.

3.9.6 Airspace

The Anchorage ARTCC airspace is bounded by the Tokyo Flight Information Region (FIR) to the southwest, the Oakland FIR to the south, the Vancouver FIR to the southeast, the Edmonton FIR to the east and Russian airspace to the west. To the north, it forms a wedge reaching to the north pole. Comprising about 2.3 million square miles, it is currently divided into 12 air-traffic control sectors. All sectors have at least partial radar coverage, but the westernmost sectors of the Anchorage FIR are mostly non-radar.

The bulk of Anchorage oceanic traffic flows along a set of northern Pacific routes called the North Pacific Composite Route System (NOPAC), which connects Japan, Korea, and other Pacific-rim nations with Anchorage and points east and south. Northerly routes under control of Oakland ARTCC may also pass through the southernmost part of Anchorage airspace.

In addition to oceanic traffic, Anchorage handles domestic civilian traffic throughout Alaska as well as a very large number of military operations. Total IFR traffic volume averages 1900 operations per day with peak days approaching 3000 operations per day.

3.10 Hawaiian Operation Systems

3.10.1 Communications

3.10.1.1 Present Communications

The communications in Hawaii are constrained by the island geography. Connections between islands are provided by undersea cable, microwave, and satellite. The mountainous terrain of the islands blocks VHF signals placed near airports and the location of stations to provide full coverage is a significant consideration.

Air-Air

The only system currently sending signals between aircraft is TCAS. TCAS is considered a surveillance system rather than a communications system and will not be addressed in this section.

Air-Ground

Air traffic communications are primarily voice. Hawaii has relatively few ATC control facilities and the Oceanic communications are handled by the Oakland ARTCC over HF. Hawaii has a single CERAP (Combined Center/Radar Approach Control) located near Honolulu, seven control towers, and a single Flight Service Station (FSS) located in Honolulu. Hawaii has 7 Remote Communications Air/Ground (RCAG) facilities and 11 Remote Communications Outlets (RCO). Figure 3.10-1 shows the locations of the RCAG facilities; figure 3.10-2 shows the locations of the RCO sites. There are no Backup Emergency Communication (BUEC) facilities.

Some data link services are in existence in Hawaii. ACARS provides AOC service via 4 stations. FANS service is available using either ACARS stations or satellite as the transmission link.

Ground-Ground

FAA operates an LDRCL (Low Density Radio Control Link) microwave system to provide connectivity between remote sites and ATC facilities. Leased telecommunications circuits which may be conventional, cable or satellite are also used. Undersea cable and satellite are used to connect Hawaii ATC to the CONUS. Hawaii has a NADIN II packet switch which provides data exchange with the rest of the NAS.

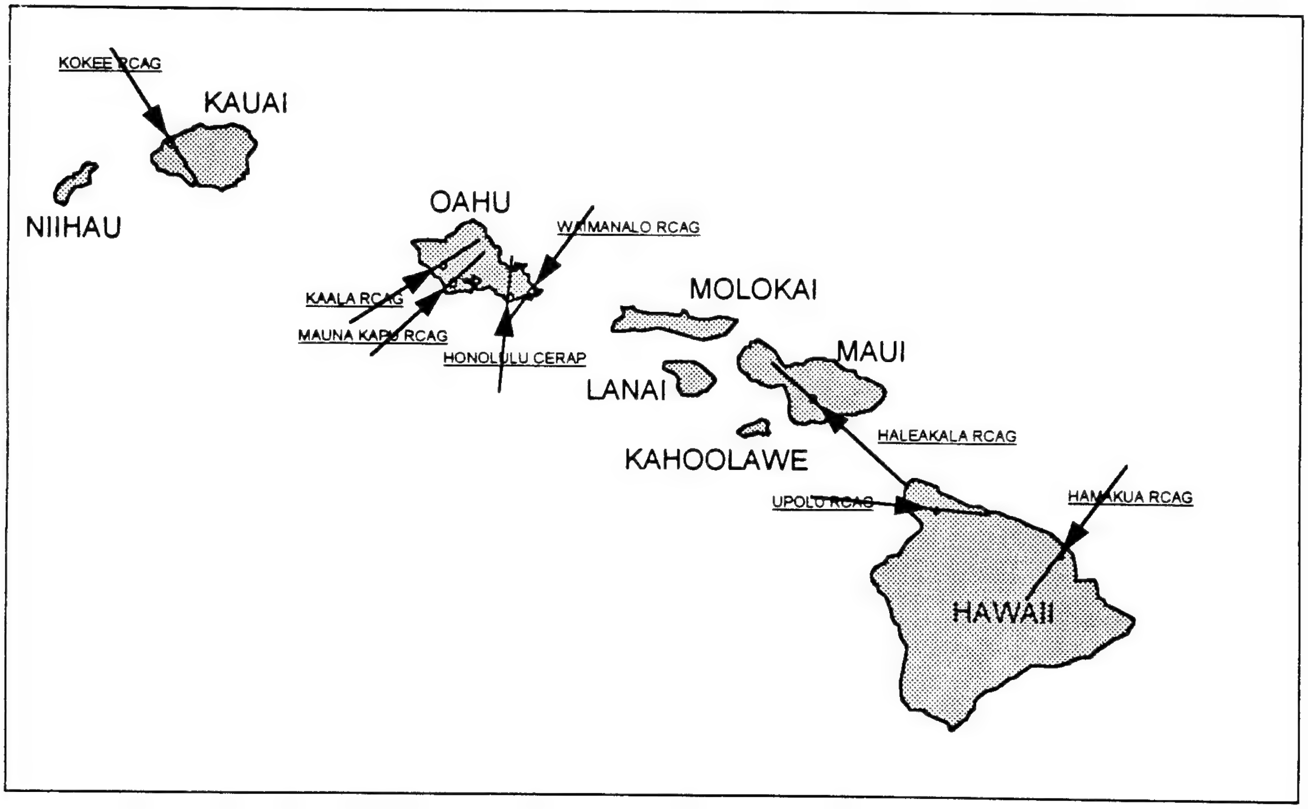


Figure 3.10-1.

Hawaii RCAG facilities

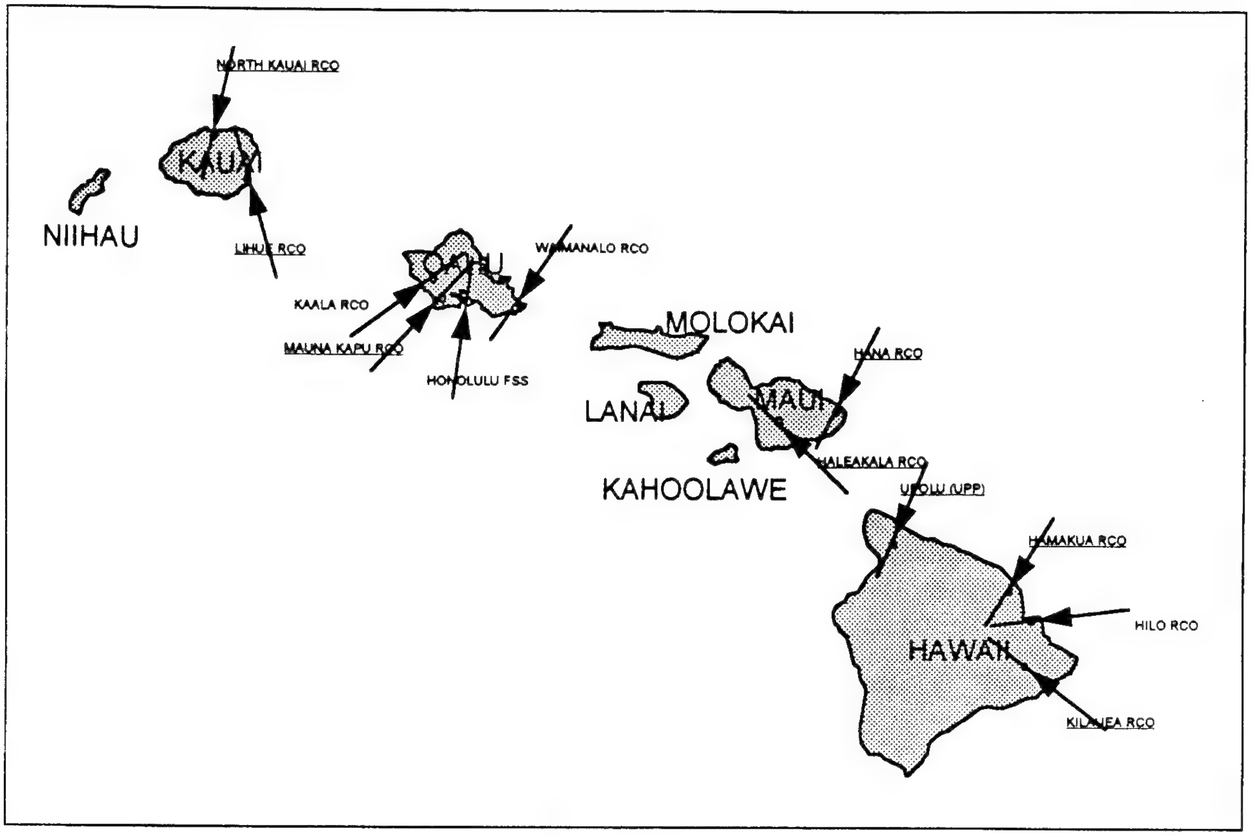


Figure 3.10-2.

Hawaii RCO sites

3.10.1.2 Future Communications

Air-Air

Future communications between aircraft will be used primarily to support the surveillance functions of ADS-B.

Air-Ground

Existing ACARS coverage is available to support Flight 2000. VDL2 stations are planned to demonstrate and validate VDL2 capability and to support Flight 2000 applications requiring a data link such as ADS-A, CPDLC and weather to the cockpit.. HF Data Link coverage is also expected by the 1999 start of Flight 2000 and can be used for Oceanic data link experiments.

Ground-Ground

Expanded ground-ground communications within the Hawaiian islands will be required to connect new VDL2 stations to ATC facilities. Undersea cable and satellite connectivity to the mainland will be required for exchange of data. Existing NADIN data transmission capacity may suffice for Flight 2000.

3.10.2 Navigation

Hawaii has 11 VORTAC or VOR/DME sites and 3 NDB sites. Figure 3.10-3 depicts their locations. No changes are expected to navigation sites for Flight 2000.

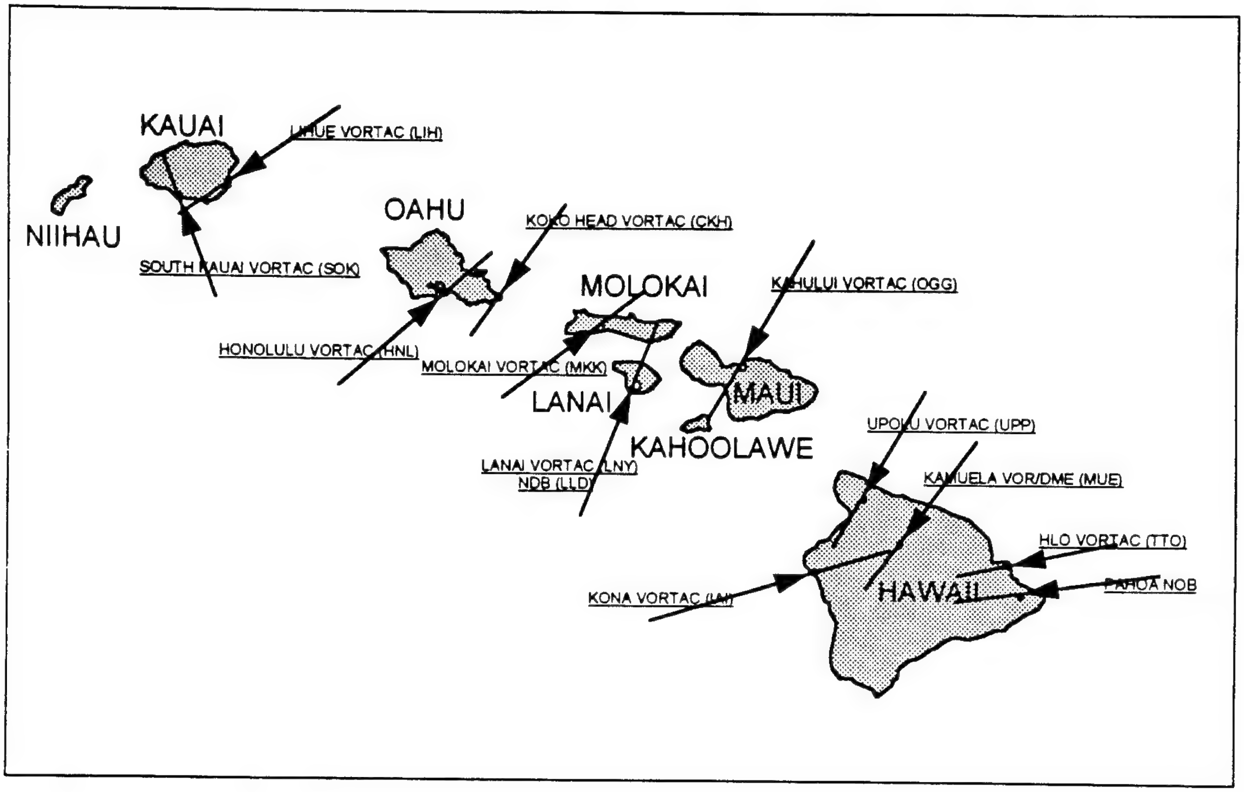


Figure 3.10-3.

Hawaii VOR/NDB Sites

3.10.3 Surveillance

There are four en route radars in Hawaii: an ARSR-4 at Mt. Kaala on Oahu, an FPS-117 owned and operated by the U.S. Air Force on Mt. Kokee on Kauai, and two beacon-only secondary surveillance radars at Puu Nianiau on Maui and Pahoa on Hawaii (Big Island). Figure 3.10-4 shows the coverages of these radars for airborne targets at 10,000 feet mean sea level (MSL). Maximum ranges at this altitude are approximately 200 nm.

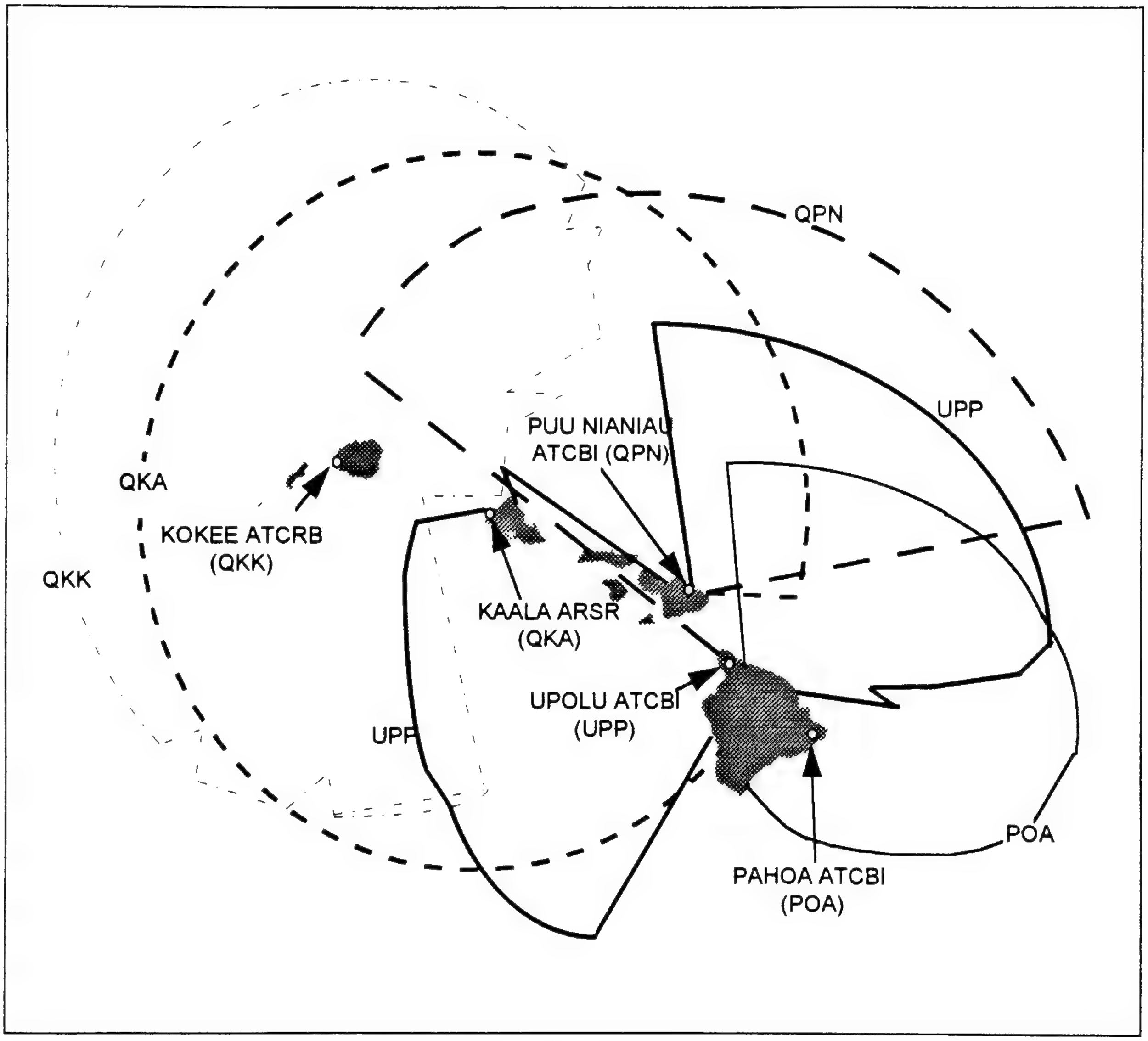


Figure 3.10-4.

En Route Radar Coverage at 10,000 ft. MSL

Hawaii has four terminal radars at the Lihui airport on Kauai, the Kahului airport on Maui, the Hilo airport on Hawaii and the Honolulu airport on OAHU. Since most of these radars are at

lower elevations near the airports, their maximum ranges are much smaller than the en route radars. All terminal radars have some blockage by mountainous terrain. There is virtually no overlapping coverage by terminal radars in Hawaii. Figure 3.10-5 depicts the radar terminal radar coverage at 1,000 feet MSL.

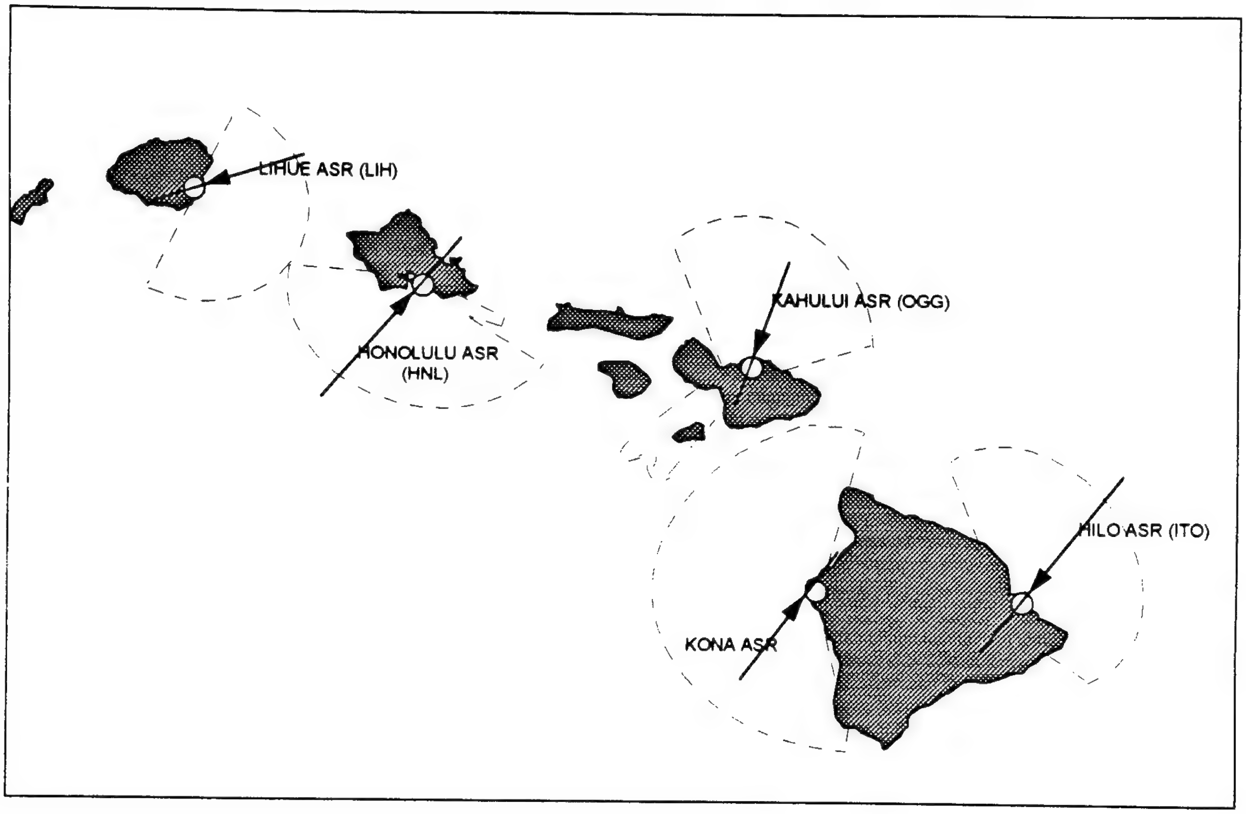


Figure 3.10-5.

Radar Terminal Radar Coverage at 1,000 feet MSL.

The following table lists the surveillance radars in Hawaii.

Table 3.10-1

Hawaiian Radar Sites

ID	SITE	Surface	Terminal Radars	En Route Radars
ITO	Hilo		ASR-8/BI-5	
QKA	Mt. Kaala			ARSR-4/BI-5
POA	Pahoa			BOS/BI-5
QPN	Puu Nianiau			BOS/BI-5
OGG	Kahului		ASR-7/BI-4	
LIH	Lihue		ASR-8L	
HNL	Honolulu			
QKK	Mount Kokee			FTS-117

3.10.4 Automation

Hilo has an Automated Radar Terminal System (ARTS) IIA, and Honolulu TRACON an ARTS IIIA. Hilo's operation is a TRACAB (TRACON in the Tower Cab) with 3 D-BRITE displays. The current Honolulu TRACON is on the airport and uses an ARTS IIIA.

The Honolulu Combined Center Radar Approach Control (CERAP) uses the Offshore Flight Data Processing System (OFDPS), which is a variant of ODAPS, along with the En Route Automated Radar Tracking System (EARTS).

The Combined Military Radar Approach Control (RAPCON) facilities at Barber's Point NAS and Kaneohe Bay MCAS use TPX-42A(V)5 automation systems. DBRITE displays are located at Wheeler AAF, Honolulu ATCT, Hilo ATCT, and Kahului ATCT.

Planned Infrastructure

The Western-Pacific Region (AWP) plans to upgrade Hilo to an ARTS IIE in May 1998. The current ARTS IIA displays will remain in operation. AWP will consolidate the Current Honolulu TRACON and the CERAP in a new facility located near the current TRACON. Installation of the consolidated HNL TRACON/CERAP is planned for completion by 30 June 2000.

When the Micro-EARTS now being installed in Honolulu CERAP becomes operational, it will drive PVDs, as the EARTS does now. A Standard Terminal Automation Replacement System (STARS) is planned for Honolulu TRACON.

3.10.5 Facilities

The CERAP, TRACON, and RAPCON facilities were identified above along with their automation equipment. The six principal Airport Traffic Control Towers are located at Honolulu (Oahu), Lihue (Kauai), Kahului (Maui), Molokai, Kona (Hawaii, "Big Island"), and Hilo (Hawaii, "Big Island").

Table 3.10-2 lists Hawaiian airports with FAA Airport Traffic Control Towers (ATCTs) or military towers.

Table 3.10-2

Hawaiian ATCT Facilities

Identifier	Location
ITO	Hilo International
BSF	Bradshaw Army Airfield
KOA	Keahole-Kona
MUE	Waimea-Kohala
UPP	Upolu
HNM	Hana
OGG	Kahului
JHM	Kapalua
LNY	Lanai
LUP	Kalaupapa
MKK	Molokai
NGF	Kaneohe Bay MCAS
HNL	Honolulu International
HHI	Wheeler AAF
HDH	Dillingham Airfield
LIH	Lihue
PAK	Port Allen
BKH	Barking Sands PMRF
NAX	Barbers Point NAS
NOP	Ford Island NALF

3.10.6 Airspace

The Honolulu airspace is bounded in all directions by the Oakland Flight Information Region (FIR). Comprising about 360,000 square miles, it is divided into nine air traffic control sectors. The bulk of traffic flows to and from the west coast of the continental United States with some traffic to the southwest and west. Inter-island traffic flows from thirteen civilian and five military airports. Total traffic volume averages about 1500 operations per day. About 20-25 percent of operations are oceanic flights.

3.11 Pacific Ocean ARTCC (Oakland Center) Operational Systems

3.11.1 Communications

3.11.1.1 Present Communications

Oakland ARTCC has a full range of communications systems to support Flight 2000 activities, including HF Voice Service.

Air-Air
The only system currently sending signals between aircraft is TCAS. TCAS is considered a surveillance system rather than a communications system and will not be addressed in this section.

Air-Ground
Oakland has full ATC coverage for the domestic routes via VHF voice. ACARS coverage is available. For oceanic control, FANS data link is available and FANS equipped aircraft do operate in the Oakland FIR.

Ground-Ground
Oakland has full ground-ground communications capability including NADIN. FAA has extensive leased telephone circuit capacity. FAA also owns and operates a high density microwave system, RCL, and LDRCL in the Oakland area.

NADIN is an electronic network for sending and receiving messages about aircraft movement within the National Airspace System, and is the primary means of providing the Oakland Center Oceanic Display and Planning System (ODAPS) with flight plans and other important information.

Three types of data are communicated to ODAPS:

1. CAO flight plans and amendments
2. Aircraft position reports and messages
3. Upper wind messages from the National Weather Service

The ODAPS clock is kept synchronized with other FAA computers by referencing the WWV radio broadcast time message.

3.11.1.2 Future Communications

For Flight 2000, existing communications systems will continue to be used in order to provide continuity of service and low risk to ATC operations. A significant addition will be the use of HF data link.

3.11.2 Navigation

The only change for Flight 2000 will be the use of the Wide Area Augmentation System (WAAS) where available that will provide higher accuracy, integrity and availability for GPS.

3.11.3 Surveillance

Currently surveillance of oceanic routes is available only within line of sight of shore-based radars. Beyond this point, aircraft position is based upon flight plan data, updated by periodic voice reports from individual aircraft. For Flight 2000, the surveillance system will consist of the Automatic Dependent Surveillance - Addressed (ADS-A) system using FANS equipment aboard selected aircraft.

3.11.4 Automation

Control of oceanic air traffic in the United States is carried out from oceanic centers located in New York, Oakland and Anchorage. The Oakland Center Oceanic Flight Information Region (FIR) uses the Oceanic Display and Planning System (ODAPS) to process oceanic flight data. ODAPS provides a tool to oceanic air traffic controllers to help them protect aircraft flying over the ocean. Unlike control centers which have real time radar data, oceanic centers have only flight plan data and radio position reports with which to locate aircraft. Separation of aircraft is performed manually through procedures. ODAPS does display each control sector and a calculated position of each aircraft in that sector, but this display is not used for aircraft separation. Processing flight plan data, position reports and upper wind data, it maintains a database with aircraft status and position. For Flight 2000 an enhanced conflict probe capability will provide additional operational improvements.

3.11.5 Facilities

The Oakland Oceanic control is co-located with Oakland Center.

3.11.6 Airspace

The Oakland Oceanic Flight Information Region (FIR) is the world's largest, covering 18.7 million square miles, or approximately 9.7% of the earth's surface. The Oakland FIR consists of two sectors with radar coverage and 8 sectors of oceanic control. The FIR extends well beyond the Hawaiian Islands and includes Guam and American Samoa. Three radar control areas (Honolulu, Guam and Bucholz Auxiliary Airfield) are surrounded by the Oakland Oceanic FIR. This creates interfaces with 14 different foreign and domestic air traffic control facilities, including Tokyo, Manila, Mexico, Tahiti, Auckland, Nadi, Port Moresby, and Biak. Figure 3.11-1 depicts the Oakland FIR.

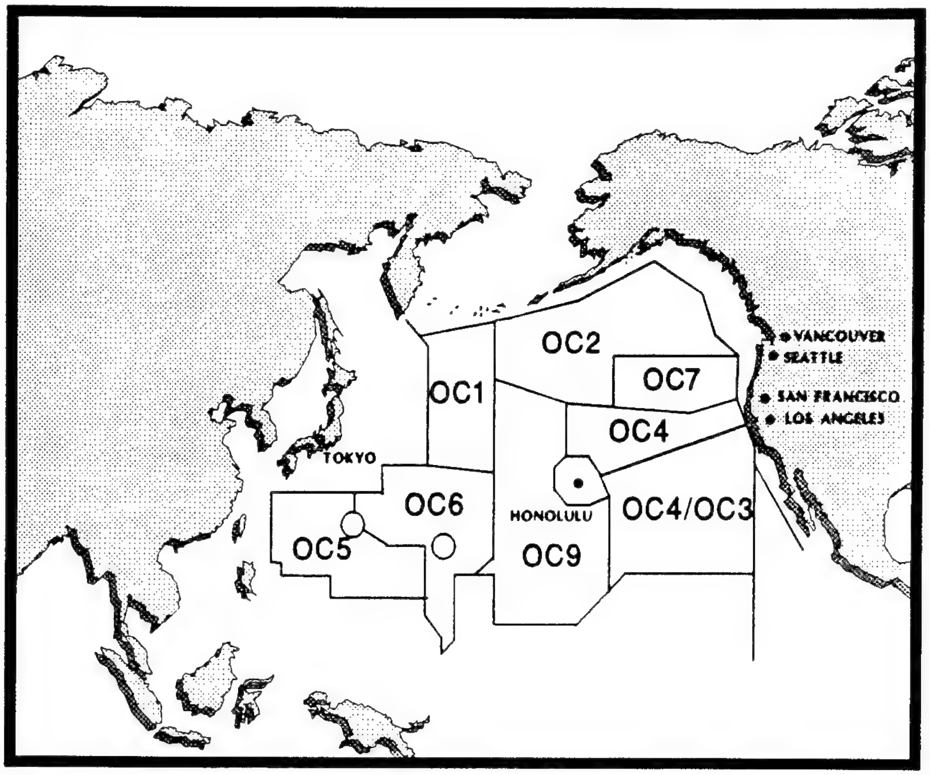


Figure 3.11-1
Oakland Oceanic Flight Information Region

The bulk of Oakland oceanic traffic flows over a complex and varied Pacific route system. A number of routes connect the continental U.S. and Hawaii with the Pacific Rim, including Japan, the Philippines, Australia and New Zealand. Another set of routes traverses the westernmost portion of Oakland airspace connecting Japan and Korea on the north with Australia and New Zealand to the south. The Pacific Organized Track System (PACOTS) provides fuel-efficient routes for long distance transpacific flights. These routes are adjusted every 12 hours in response to upper level wind conditions. The most northerly routes are grouped in the North Pacific Composite Route System (NOPAC), whereas the traffic between the continental U.S. and Hawaii flies on the six Central East Pacific Composite Route System.

3.11.7 <u>Users and Equipment</u>

Over 560 flights are handled on a daily basis by the Oakland Center FIR. Thirteen of the top 25 busiest routes in the world are in the Asia/Pacific region. Oakland Center is projected to have three of the top five busiest routes: Guam-Tokyo, Honolulu-Tokyo, and North America-Toyko.

4.0 CAPABILITIES

This section describes the architecture of the enabling capabilities which will be available for Flight 2000. Each capability is described in relation to its functionality towards enhancing air traffic. Benefits of each capability are described and the planned deployment strategy is laid out. There are many interfaces with these capabilities, in fact, the system of capabilities is where most of the benefits lie. Each capability not only has many interfaces, but also depends upon other capabilities. Table 4.0-1 summarizes the information presented in this section. Additional details are presented following the summary.

Table 4.0-1 Flight 2000 Enabling Capabilities

Enabling Capability	Brief Functional Description	Benefits and Operational Improvements	Deployment Configuration	Integration and Interfaces
Wide Area Augmentation System (WAAS)/ Local Area Augmentation System (LAAS)	-- WAAS uses ground stations and satellites to improve the aircraft navigation accuracy obtainable with the Global Positioning System (GPS) to about 7 meters -- LAAS uses local ground stations to provide 1-meter navigation accuracy within approximately 30 miles of an airport for precision approach and landing	-- WAAS provides much **more accurate** and more highly **available** aircraft **navigation** service than conventional terrestrial navigation aids in virtually all U S. airspace -- LAAS **improves** on the **accuracy and availability** of current **precision landing** systems -- Both systems **will reduce** significantly the **operation and maintenance costs** of today's ground-based navigation and landing systems	-- WAAS ground stations will provide coverage throughout Hawaii and most of Alaska, including approaches to villages -- LAAS precision approaches at Anchorage, Juneau, Bethel, Honolulu, Hilo, Kahului, Lihue, Kona (HI)	-- WAAS and LAAS augment current GPS navigation signals -- WAAS and LAAS position information are transmitted via ADS-B for surveillance and displayed in the cockpit for situational awareness
Automatic Dependent Surveillance-Broadcast (ADS-B)	-- ADS-B avionics periodically broadcast aircraft position information derived from WAAS or LAAS to enable other aircraft and ground systems to perform surveillance of equipped aircraft on the airport surface or in terminal and en route phases of flight	-- Enables **longer-range** air-to-air **detection** and **more accurate** surveillance than TCAS -- Provides **more accurate ground-based surveillance** than current primary and secondary radar, thus **reducing false and missing alerts** in terminal and en route Conflict Alert and Minimum Safe Altitude Warning functions -- Affords **more extensive coverage** at **significantly lower** acquisition, operation, and maintenance **cost** than primary or secondary radar	-- En route ADS-B surveillance at Anchorage ARTCC and Honolulu CERAP, including some coverage for terminal approaches -- ADS-B surveillance on STARS at Anchorage and Honolulu TRACONs -- Terminal ADS-B surveillance at Juneau, Bethel, Dillingham, Nome (AK), Hilo, Kahului, Lihue, Hoolehua, Kona (HI) -- Surface ADS-B surveillance with multilateration at Anchorage and Honolulu airports	-- ADS-B transmissions are received by other aircraft for situational awareness -- ADS-B transmissions to ground stations are forwarded via existing FAA communications networks to surveillance fusion processors and ATC automation systems -- Radar and traffic information may be combined with ADS-B data to provide a composite position report
Controller-Pilot Data Link Communications (CPDLC)	-- CPDLC enables routine clearances and other messages to be transmitted between air traffic control facilities and the cockpit via ground- or satellite-based transceivers without voice communication	-- **Reduces frequency congestion** on current voice channels -- **Eliminates communications errors** caused by human speech and hearing anomalies -- Provides a **record of past transmissions** that can be easily reviewed -- **Improves efficiency of controller and pilot** performance	-- CPDLC using FANS equipped aircraft, migrating to ATN, in Oakland oceanic sectors, extending into en route sectors on the Oakland Display System Replacement (DSR)	-- CPDLC applications in the aircraft and on the ground process and route data link communications and display appropriate messages to pilots and controllers
Flight Information Services (FIS)/ Cockpit Information System (CIS)	-- FIS uses a ground-based data server and data links to provide a variety of information to the cockpit including weather products, traffic information, Special Use Airspace status, Notices to Airmen (NOTAMs), obstruction updates, digital ATIS, and other flight information -- the CIS processes and displays FIS information and integrates it with navigation, surveillance, terrain, and other data available in the cockpit	-- **Improves** cockpit **situational awareness**, and thus overall **safety** of operations -- Facilitates operations over **more direct routes** by enabling weather patterns and SUA status to be factored into route selection -- Integrated CIS supports **more efficient cockpit decision-making** at a **significantly lower cost** than discrete avionics packages	-- FIS processor/servers at Anchorage ARTCC and Honolulu CERAP -- Data link transceivers and FIS services deployed at Anchorage, Juneau, Bethel, Dillingham, Nome (AK); Honolulu, Hilo, Kahului, Lihue, Hoolehua, Kona (HI), and at Hawaii remote ADS-B sites -- D-ATIS provided at Anchorage and Honolulu airports only -- FIS products provided at Alaskan villages within line of sight to Flight Service Station transceivers -- Traffic Information Service via HNL Mode S	-- FIS data are processed and distributed from central FIS servers via existing FAA communications networks -- FIS transceivers communicate the server data between the ground and the aircraft -- the CIS integrates most cockpit navigation, surveillance, and communications capabilities in a single avionics unit
Decision Support System (DSS)	-- DSS involves integrating a variety of automated tools, such as the Dynamic Ocean Tracking System (DOTS), oceanic conflict probe, and Enhanced Traffic Management System (ETMS), to assist controllers and traffic flow managers in planning preferred aircraft routes and in approving in-flight changes to those routes in collaboration with airline operation centers and aircraft operators	-- Enables **more frequent** and consistent granting of **user-preferred routes** -- **Improves efficiency of controller and pilot** performance -- Substantially **reduces aircraft delays** and the resulting penalties in **time, fuel, and other operating costs**	-- Enhanced conflict probe and DOTS/ETMS integration at Oakland ARTCC oceanic sectors	-- DSSs communicate via existing FAA communications networks with the Air Traffic Control System Command Center and via voice or data networks with Airline Operations Centers and aircraft operators -- DSSs are resident on Traffic Management Units and on en route, oceanic, and terminal ATC automation platforms

The Flight 2000 technical architectures are dependent upon the timing and level of funding. Detailed site surveys and refinement of technical architectures will be completed upon receipt of Flight 2000 project funding. In addition, aircraft that would receive avionics will then be identified. A site survey

team would be formed made up of representatives from the integrated product teams and the regions to document necessary site information. As a minimum, the following would be required:

- Equipment siting locations
- Power availability
- Environmental impacts
- Need for facility space
- Nearest communications links (air and ground)
- Additional communications needed
- Existing available communications capacity
- Training and support requirements
- Impact of Flight 2000 on ongoing and planned local projects
- Local air traffic control procedures and operating waivers
- Determination of spectrum needs and analysis of coverage requirements
- Local ability to support the evaluations and conduct data collection
- Interviews with controllers and pilots to capture concerns and issues
- Interviews with system maintainers who would support installation and maintenance of new capabilities to capture their concerns and issues
- Coordination with local and Department of Defense participants on capabilities and schedules
- Test bed opportunities due to the unique characteristics of the site
- Other issues unique to the specific capability to be demonstrated and evaluated

Once the site surveys are completed, the project description and the operational test and evaluation plans developed by the integrated product teams will be used to define the technical architecture. By this time, sufficient information will be available to diagram the interfaces and connectivity to the different existing and new components of the demonstration and evaluation. The technical architecture will be accomplished by a system engineering team composed of representatives from the integrated product teams, regional and local personnel, and Architecture and System Engineering, in collaboration with the user community.

4.1 The GPS/WAAS/LAAS Navigation System

4.1.1 Functional Description

The navigation system for Flight 2000 will consist of an integrated mix of existing and new technologies. Existing ground-based technologies include VOR, ILS, TACAN, DME and NDB systems. These technologies are not discussed here. New space-based technologies include GPS, WAAS, and LAAS. A brief description of each component of the GPS/WAAS/LAAS navigation system follows.

4.1.1.1 Global Positioning System (GPS)

GPS is a satellite-based radio-navigation, positioning, and time transfer system operated by the DoD. GPS consists of three major segments: space, control and user. The space segment consists of 24 operational satellites placed in 20,200 Km, 12 -hour (approximately) orbits, evenly spaced in six orbital planes. The satellites are positioned such that a minimum of five satellites will be in view anywhere in the world at any time. The satellites transmit L1 and L2 navigation signals. The L1 signal (1575.42 MHz) carries the coarse acquisition code (C/A Code) and the precision code (P-Code). The L2 signal (1227.6 MHz) carries only the P-Code. GPS provides two levels of service: a standard positioning service (SPS) and a precise positioning service (PPS). All users will have access to the C/A codes for SPS, but only selected users who require full system accuracy will have access to the P codes for PPS. Added to the C/A and P codes is the navigation message which contains data on the status of the satellite, the time synchronization, and the ephemeris of the satellite.

The control segment consists of a single master control located in Colorado Springs, and five monitor stations in Hawaii, Colorado Springs, Ascension, Diego Garcia, and Kwajalein that passively track and collect ranging data from all satellites. The data are sent to the master control station where they are processed to determine the precise satellite orbits and errors. The master control station updates the navigation message for each satellite. The user segment consists of GPS receivers, with one or more channels, and accessories. Using the navigation signals transmitted by the satellites, a user's receiver derives three dimensional positions and accurate time.

4.1.1.2 WAAS

The Wide Area Augmentation System (WAAS), is a space-based augmentation system (SBAS) that enhances GPS standard positioning service (SPS) information by providing improved required navigation performance (RNP) in accuracy, integrity, continuity of service, and availability. The WAAS navigational message improves the GPS signal accuracy from 100 meters to approximately 7 meters. WAAS will be used as a primary means of navigation during all phases of flight through Category I (Cat I) precision approaches. WAAS provides greater efficiency with respect to minimizing the required number of ground facilities in providing continental coverage. For precision approach, it makes use of a differential technique that provides separate corrections for satellite clock error, ephemeris error and ionospheric delay based on observations from a minimally-distributed network of reference stations. The

corrections are broadcast via special transponder payloads on geostationary communications satellites in the form of digital data contained in GPS-like signals. WAAS will prove enormously beneficial to both the FAA (as a navigation service provider) and to users of US airspace alike. It will enable the FAA to eventually decommission a vast inventory of terrestrial navigation aids, (VOR, DME, etc.) at significant savings in operations and maintenance cost while serving as a critical enabling technology for free flight.

Under Phase I of the WAAS deployment, the operational configuration will have two master stations, 24 reference stations, leased geostationary communications satellites, and ground uplinks to achieve a supplemental Cat I precision approach capability. This supplemental capability will begin the transition to satellite-based precision approaches, but will not be certified for stand-alone operations until the latter stages of the Flight 2000 operational evaluation.

WAAS will provide nonprecision capabilities with LAAS providing augmentation for precision approaches.

Phase II will expand the initial configuration by providing additional master stations, reference stations, and communications satellites as required. Phase III will complete the end state WAAS to provide stand-alone Cat I approach capability by providing additional master stations, reference stations, and communications satellites.

Like GPS, the WAAS consists of three segments. The ground segment will consist of 24 wide area reference stations (WRS), two wide area master stations (WMS), and geostationary earth orbit (GEO) uplink stations (GUS). Each precisely surveyed WRS performs the following functions: data collection, reasonability checking, data processing, data recording, and data transferring to the WMS via a terrestrial communications system (TCS). The WRS contains multi-channel receivers, antennae, precise time references, power supplies, data processors, and accessories. The WMS processes the data to determine the integrity, differential corrections, and residual errors for each monitored satellite, and for each predetermined ionospheric grid point. The WMS contains data processors and ancillary equipment. The data processed at the WMS is sent to a GUS, via a TCS. The GUS in turn uplinks data to GEO satellites.

The space segment consists of the 24 operational GPS satellites described above and GEO satellites. The GEO satellites downlink the data to the users on the GPS Link 1 (L1) frequency with a modulation similar to that used by GPS. Information in the navigational message, when processed by a WAAS receiver, allows the GEO satellites to be used as additional GPS-like satellites, thus increasing the availability of the satellite constellation.

The user segment consists of a multi-channel receiver and accessories that receive data from both GPS and GEO satellites, and provide precise positioning indications to a cockpit display subsystem, and/or to a surveillance subsystem.

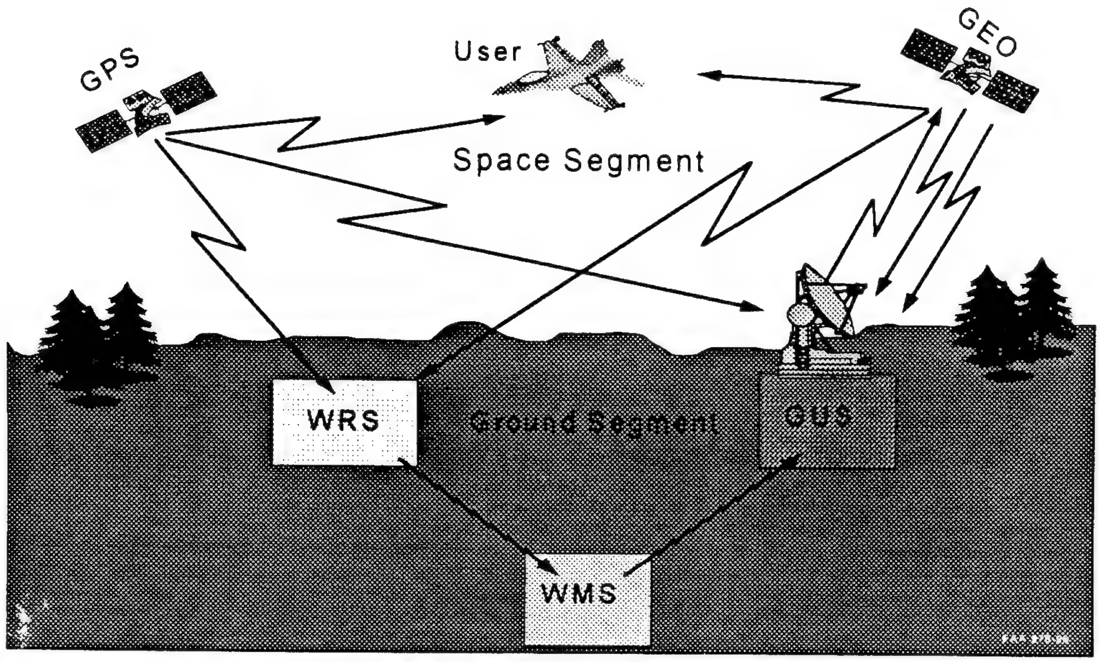


Figure 4.1-1.
WAAS Communications Links

4.1.1.3 LAAS

The Local Area Augmentation System (LAAS) is intended to complement WAAS service. LAAS uses a single differential correction that accounts for all expected common errors between a local reference and users. Hence, LAAS will broadcast navigation information in a "localized" service volume of approximately 30 NM. This service volume would typically encompass a specific airport or airports within close proximity. Although the service volume of LAAS is much smaller than WAAS, LAAS provides greater accuracy than WAAS. LAAS should, therefore, be able to provide precision-approach service beyond the capability of WAAS. This service includes all Category I precision approach requirements (higher availability than WAAS), Category II instrument approaches, and Category III instrument approaches and landings. Additionally, the quality and accuracy of the LAAS signal should provide new services such as airport surface navigation and sensors for automatic dependent surveillance (ADS) in low visibility. The LAAS architecture will permit inclusion of other GNSS elements such as the Global Navigation Satellite System (GLONASS) when deemed to be operationally acceptable. LAAS will operate independently of WAAS while being fully compatible with it. This will enable LAAS to provide a satellite-based, independent backup to WAAS service within the US. The ground system will be modular in design to accommodate CAT I through CAT III requirements.

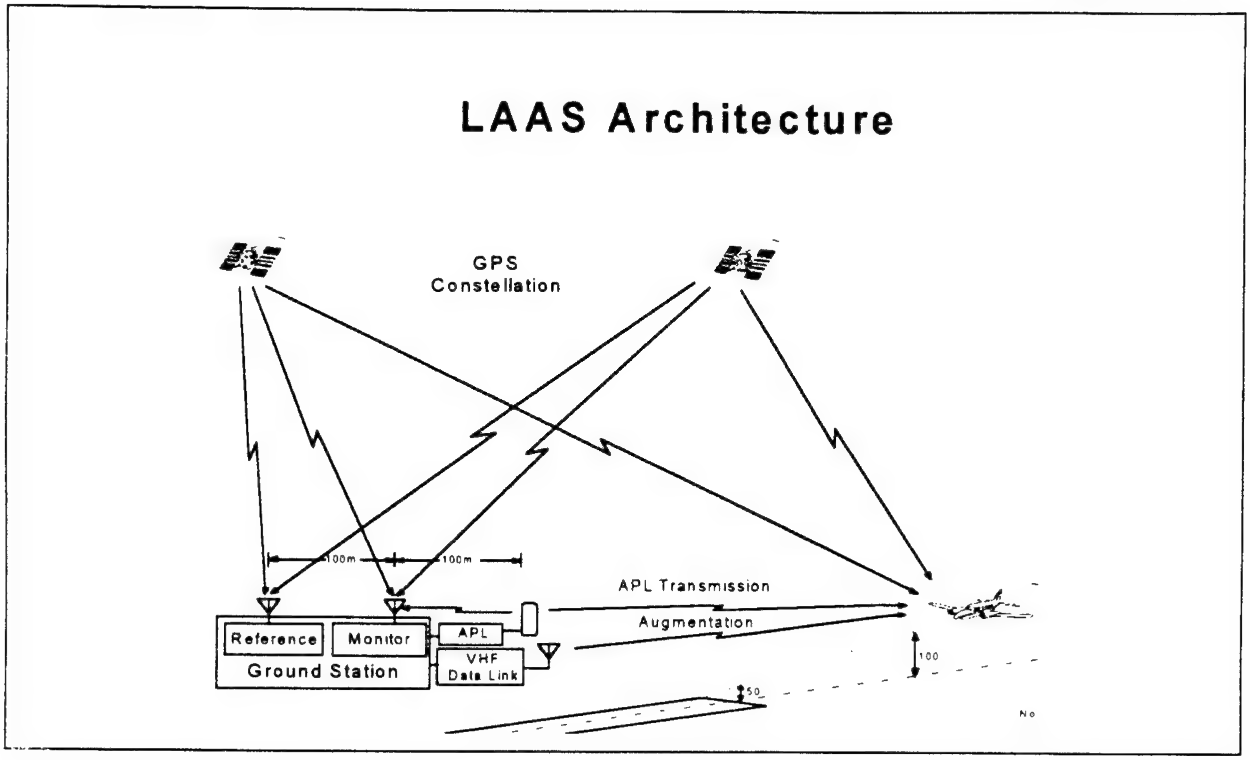


Figure 4.1-2.
LAAS Architecture

The LAAS architecture includes a ground station with multiple receivers, pseudolites, and a VHF radio navigation data link. The location of the ground station is carefully selected to insure optimum performance. The LAAS ground station compares the position calculated using its GPS receivers to the actual surveyed position of the station. The difference between these positions is placed in a correction message which is broadcast to all users within a 20 to 30 mile radius. The output of the LAAS receiver will provide precise positioning indications to a cockpit display subsystem, and/or to a surveillance subsystem. Airport pseudolites (APL), which are ground-based transmitters of GPS-like signals, will be selectively used at airports to provide additional signals to meet availability requirements.

4.1.2 GPS/WAAS/LAAS Benefits and Operational Improvements

The space-based navigation system is the source of a wide number of navigation-related benefits. In addition, the GPS/WAAS/LAAS system enables a number of surveillance benefits, building on the increased availability of accurate navigation information for the majority of NAS users that can not afford the higher accuracy provided by inertial navigation systems (see 4.2.4). The following are some of the benefits that will accrue from the use of a space-based navigation system:

- **Additional departure routes, arrival routes, and precision approaches based upon satellite navigation aids**. Because current navigation depends on ground navaids, many routes are cumbersome and inefficient. By using GPS waypoints, new routings can be designed to get aircraft into and out of the airport more quickly and more safely.

- **Increased pilot situational awareness**. GPS improves pilot situational awareness, especially when combined with moving map displays, both airborne and on the airport surface. This benefit is magnified when navigation information is integrated with other cockpit information and displays (see Section 4.4).

- **Increased use of low-altitude direct routes using GPS navigation**. With GPS, many constraints of airways based upon ground based navigation aids are eliminated. Navigation waypoints can be defined at any location, instead of only at those points where a VOR or other ground based aid can provide the positional information to establish a fix or crossing radial. This greatly increases the flexibility of airway route construction, resulting in more direct routes for operators, especially those at lower altitudes where lines of sight to ground based navigation aids are more restricted due to terrain blockage or curvature of the earth.

- **Increased airspace flexibility and accessibility through reduced separation minima**. Separation minima are based on the total CNS/ATM capabilities of users and service providers in a given airspace. In cases where navigation accuracy is a limiting factor, satellite -based navigation can support reduced separation minima. Other improvements, such as satellite communications, higher accuracy altimeters, and modified air traffic control procedures, will also contribute to a reduction in separation requirements. Reducing separation minima will allow more aircraft to fly at their optimum altitude, speed and routing, increasing flexibility and reducing costs for the operator.

- **Additional non-precision approaches.** WAAS will provide navigation accuracies that will give non-precision instrucment approach capability to many airports that currently have no instrument approaches. WAAS would also give to some airports the capability to add CAT I precision approaches. Both of these improvements to approach capabilities would provide significant benefits of fewer weather delays, safer operations and improved economics to regional and commuter airlines as well as general aviation, both fixed wing and rotor aircraft.

- **Increased flight operations efficiency**. With more routes available to users via satellite navigation, one of the resulting benefits will be lower costs to the operator.

4.1.3 Deployment Configuration

The user's onboard navigation system receives inputs from all available navigation sources, processes those inputs, and develops a position and velocity solution. On large commercial aircraft, an Flight Management System (FMS) function then adds intended position, velocity, and addressing information (ICAO address). This position solution is then provided to the display avionics for the pilot and the surveillance system for broadcast. Position information of other aircraft is developed from the surveillance system, processed through the FMS or other computing resource, and presented to the pilot's display.

4.1.3.1 GPS

GPS will be used in Hawaii, Alaska, and parts of the Oakland Flight Information Region (FIR) in the following classes of aircraft: air carrier, commuter, general aviation, and military. Parts of the Oakland FIR that are beyond the coverage of the WAAS will utilize the GPS navigational system. GPS receivers installed in aircraft will be used to determine positions for surface, terminal, en route and oceanic phases of flight. The receivers will derive their positions from an existing constellation of GPS satellites. Receiver autonomous integrity monitor (RAIM) capability will be included in all GPS receivers

4.1.3.2 WAAS

The WAAS will be used in Hawaii, Alaska, and parts of the Oakland FIR which fall under WAAS coverage. A minimum of three (3) reference stations will be required in Alaska, and a minimum of two (2) reference stations will be required in Hawaii. Since the current WAAS implementation schedule includes only one reference station each for Alaska and Hawaii, additional stations will be installed for Flight 2000. The WAAS architecture includes reference stations in Seattle, Oakland, Los Angeles, and Salt Lake City that may cover a portion of the Oakland FIR. Reference stations used to provide corrections about a given geographical area will be connected to a master station located in Los Angeles. In some cases, the data collected by the reference station could be sent to the master station, via a satellite. It should be noted that WAAS receivers will continue to provide GPS (Standard Positioning Service) navigation beyond the range of the WAAS coverage. The WAAS will be used in the following classes of aircraft: air carrier, commuter, general aviation, and military.

4.1.3.3 LAAS

The LAAS will be used in Alaska at a minimum of three sites. Alaska sites will be selected based on cost, necessity, environmental conditions, and user input. Anchorage has been selected as one of the sites to take advantage of the opportunity to demonstrate Category III approach capability in Anchorage. Other locations currently planned are Juneau and Bethel. In Hawaii, LAAS sites are planned for the five major airports that are currently ILS equipped. These sites are: Honolulu, Kahului, Kona, Hilo and Lihue. By providing LAAS at each of the airports and equipping aircraft with appropriate avionics, an evaluation of the feasibility of decommissioning the ground based ILS will be made. The LAAS will be used in the following classes of aircraft: air carrier, commuter, general aviation, and military.

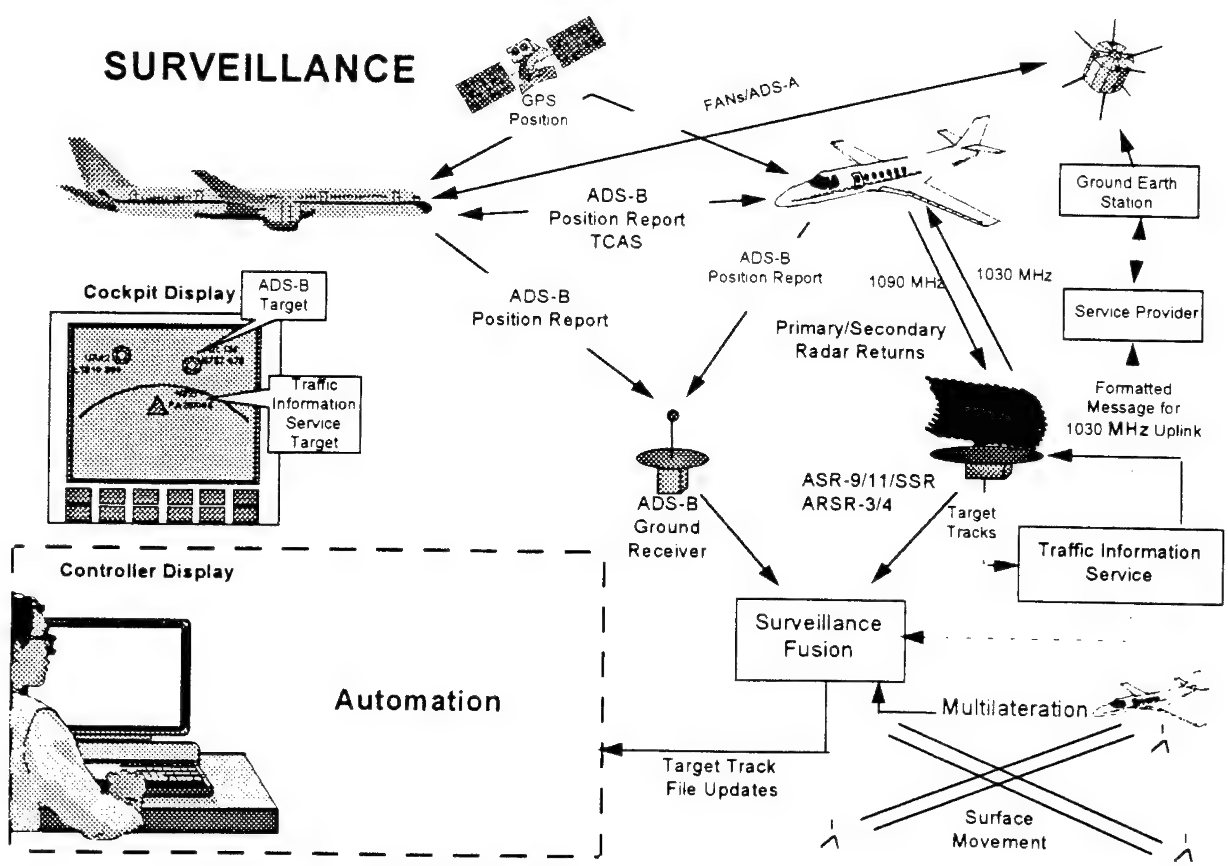
4.2 Surveillance System

4.2.1 Functional Description

The surveillance system for Flight 2000 will consist of an integrated mix of surveillance technologies, including primary and secondary radar, multilateration, ADS-A and ADS-B. The primary radar component of the surveillance subsystem will consist of existing FAA radars, including ARSR, FPS, ASR, and ASDE. It is anticipated that no additional primary radar coverage will be required for Flight 2000 beyond current levels. The secondary radar component of Flight 2000 will consist of the existing FAA Mode S radar beacon system. The Mode S radar beacon system will provide surveillance on Mode S and Air Traffic Control Radar Beacon System (ATCRBS) Mode A and Mode C equipped aircraft. The multilateration component for use on the airport surface will consist of an array of ground stations capable of multilateration on Mode S short squitters and ATCRBS replies elicited by active ATCRBS whisper-shout interrogations. The ADS-A component will be the existing FANS system in use in the Pacific.

Initially, the ADS-B component will be the Mode S extended squitter with active range validation. Flight 2000 will also investigate other promising approaches for transmission of ADS-B data. Figure 4.2-1 depicts the architecture for surveillance information flow.

Figure 4.2-1. Surveillance Architecture



The particular mix of technologies used for each operational domain is described below.

Airport Surface

The airport surface surveillance system will consist of a combination of Airport Surface Detection Equipment (ASDE), multilateration, and ADS-B. The highest capability surface surveillance system to be used at the largest airports (e.g. Anchorage) will employ an ASDE-3 and a multilateration system with ADS-B capability. This will provide integrated surface surveillance on non-cooperative targets, ATCRBS (Mode A/C) aircraft, and Mode S aircraft, including those with extended squitter (ADS-B) capability.

Surface vehicles operating in the movement area of the airport will be equipped with Mode S short or extended squitter transmitters. A lower capability surface surveillance system for smaller airports may be based on ADS-B ground stations.

Terminal Area

Two types of surveillance systems will be used for the terminal area of an airport. For airports with an existing ASR and beacon radar (e.g. Anchorage, Honolulu) the terminal area surveillance system will consist of an ASR primary radar with a Mode S or ATCBI secondary radar. The secondary radar will provide surveillance on ATCRBS (Mode A/C) aircraft and Mode S aircraft. Where a Mode S is installed, it will provide enhanced surveillance on Mode S aircraft equipped with extended squitter (ADS-B) by downlinking the ADS-B information from the Mode S transponder data registers with an active interrogation. This will permit ground-based decision support systems to have access to the improved aircraft position, identity, state, and intent information that they require. It will also permit independent real-time validation of the ADS-B position information and allow the air traffic service provider to monitor the quality of the surveillance information used by flight crews for self separation procedures. For airports without an existing ASR or beacon radar, (e.g. Bethel, Alaska) the terminal area surveillance system will consist of ADS-B ground stations.

En Route Airspace

For en route airspace with an existing primary and secondary radar, the en route surveillance system will consist of the primary radar and Mode S or ATCBI radar beacon sensor. The operation of the combined primary and secondary radar will be similar to the combined operation described above for the terminal area. For en route airspace without an existing primary and secondary radar, the en route surveillance system will consist of an ADS-B ground station as described above for the terminal area. In addition, ADS-A will be used in selected high altitude non-radar regions of Alaska.

Oceanic Airspace

For oceanic airspace, the surveillance system will consist of ADS-A via FANS1/A.

Air-Air Surveillance (all Airspaces)

In all airspaces, ADS-B will provide an air-to-air surveillance capability. In regions where there is sufficient equipage with ADS-B, this air-to-air surveillance will improve safety by providing better situational awareness and allow for additional airspace improvements (e.g., user preferred routing, reduced separation minima).

4.2.2 Functional Characteristics

ADS-A Messages

Automatic Dependent Surveillance Addressed (ADS-A) is an existing service in oceanic airspace. The ADS-A messages currently provide aircraft identification, latitude, longitude, altitude, and other related data. No change from the current content of the ADS-A messages is planned for Flight 2000. However, the operational domain of ADS-A will be increased to include some high-altitude non-radar Alaskan airspace.

ADS-B Messages

ADS-B is a technique whereby aircraft position and velocity is derived by an onboard GPS receiver and aircraft identity, altitude and position are broadcast directly to the ground and nearby aircraft. For Mode S equipped aircraft, the onboard ADS-B transponder will broadcast (squitter) on the international transponder reply frequency of 1090 MHz. With current Mode S/TCAS equipment capabilities, an ADS-B equipped aircraft is expected to provide surveillance information to other in-flight aircraft at ranges up to 40 NM and to ground stations at distances up to 95 NM.

The operational requirements for the reception of ADS-B information from cooperative targets depends on the application performed (e.g., en route ATC surveillance, aircraft-to-aircraft stationkeeping, or surface conflict detection). These application-dependent requirements are detailed in the ADS-B MASPS.

The ADS-B function within an aircraft shall be capable of providing position reports containing identification, latitude, longitude, altitude, speed, heading, and possibly other information based on the results of ongoing MOPS development by RTCA.

ADS-B Minimum Capability

Aircraft and ground vehicles participating in ADS-B will, at a minimum, be capable of providing periodic broadcast reports containing the following information: latitude, longitude, barometric altitude, and ICAO address of the aircraft. Velocity information will also be included in the ADS-B messages when available from the onboard navigation system (e.g., GPS). This minimal ADS-B capability will support airborne and surface surveillance, situational awareness, and ATC surveillance during Flight 2000.

Mode S Radar

Mode S Radars are currently being established in the NAS. Mode S allows for selective addressing/interrogation of aircraft. Mode S also incorporates monopulse techniques to calculate the position of aircraft. These features help minimize the number of false target reports and allow azimuth accuracy to within 1 milliradian RMS. To date there are 75 Mode S systems in full operation with an additional 34 operating in IBI Mode. The 34 IBI and remaining 35 systems require en route software upgrade or Beacon Video Reconstitutor upgrade in order to achieve full Mode S capability. These upgrades are planned to be completed and installed by the end of 1998 bringing the total number of full Mode S systems to 144. For Flight 2000 the existing beacon system at Anchorage will be replaced with a Mode S sensor.

Mode S ADS-B Ground Stations

The ADS-B ground system is a listening receiver/transmitter (R/T) system, capable of receiving GPS derived ADS-B reports and interrogating and receiving Mode S squittered replies via 1030/1090 MHz data link. The system, which is modular in design, includes an omni or sector receiver/transmitter antenna, and associated processor(s). For en route applications, R/T units will be located in remote locations in support of Flight 2000 in Alaska to provide the surveillance coverage needed in existing non-radar areas. Surveillance information can be provided to service users via existing land or satellite (ANICS) communications networks.

ADS-B/Mode S Multilateration

For terminal and surface applications, several R/T units will be configured to perform multilateration via Mode S replies. For remote terminal applications, surveillance information can be provided to service users via existing land or satellite (ANICS) communications networks.

Multi Sensor Interface Processor

The Sensor Fusion Integration Function (ground station) is capable of accepting the surveillance data from the en route ADS-B receivers, the Mode S sensor, the terminal ADS-B multilateration subsystems, and the ground ADS-B subsystems, and creating a unified track database.

4.2.3 Performance Characteristics

ADS-A Messages

ADS-A aircraft participating in Flight 2000 shall satisfy the performance characteristics described in "Minimum Operational Performance Standards for Airborne Automatic Dependent Surveillance (ADS) Equipment" - RTCA/DO-212. No change to the current report transmit rates in oceanic airspace will be required for Flight 2000.

ADS-B Messages

RTCA Special Committee 186 (SC-186) is tasked with developing U.S. standards for ADS-B. SC-186 has prepared draft MASPS for ADS-B and has started to develop MOPS for extended squitter. In addition, the ICAO SICAS (SSR Improvements and Collision Avoidance Systems) Panel has approved SARPS for extended squitter. The end-to-end delay, availability, and integrity of the ADS-B reports during Flight 2000 will satisfy the requirements given in "Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)" RTCA SC-186.

The reception rate requirements for the ADS-B broadcasts will depend on the surveillance operational improvement(s) being supported.

4.2.4 Surveillance Benefits and Operational Improvements

Automatic Dependent Surveillance - Broadcast (ADS-B) is an aircraft surveillance technique that will be used for a variety of applications. Use of ADS-B will provide enhanced ATC surveillance where it is not economical to provide radar surveillance. Because ADS-B can enhance knowledge of proximate traffic in the cockpit, procedures can be extended or added that include a CDTI as an element of separation. Benefits and operational improvements associated with the surveillance improvements in Flight 2000 include the following:

- **In-trail climb (ITC) and in-trail descent (ITD).** ADS-B would enhance the ITC and ITD procedures that have already been certified on a trial basis for certain portions of oceanic airspace under U.S. air traffic control by increasing the range over current TCAS II capability. The current procedures authorize the use of the TCAS II traffic display for aircraft to climb or descend through the altitude of same direction traffic at separations considerably lower than standard non-radar separations, when certain display adequacy requirements are satisfied and the required training has been accomplished. See Figure 4.2-1. The ITC procedure facilitates fuel savings for aircraft thus reducing the potential for costly diversions. Both the ITC and the ITD procedures provide operational flexibility such as avoidance of turbulence.

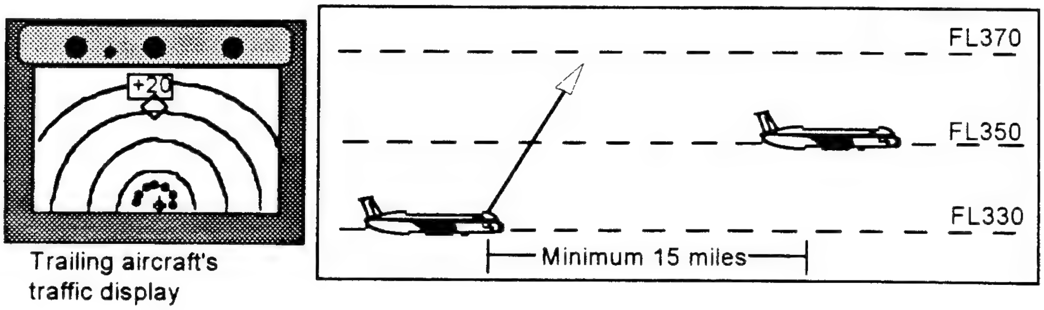


Figure 4.2-2. The ITC Concept

- **Lead climbs (LC) and lead descents (LD)** These are an expansion of ITCs and ITDs and are possible because of ADS-B's ability to "see" aircraft in the aft quadrants. The procedures would be similar to the ITC and ITD, but the climbing or descending aircraft would be in the lead. Benefits would be similar to ITCs / ITDs.

- **Reduced taxi delays in low visibility operations**. Using aircraft GPS position information augmented by higher accuracy WAAS and LAAS information, aircraft will broadcast these positions to other nearby aircraft and to ground controllers. Because controllers will no longer have to rely strictly upon having visual sight of each aircraft for positive control, aircraft will be able to taxi to and from runways with fewer delays than are currently incurred. This reduction in delays at the gate or upon the airport surface will result in less fuel burned, less fuel which must be carried onboard the aircraft, less cost based upon engine operation time, and greater profits for the commercial carrier. Increased safety will also be a benefit to this technology as controllers are more aware of aircraft position. Also properly equipped aircraft will also be able to monitor positions of other aircraft on the airport surface and insure adequate separation is maintained.

- **Increased pilot situational awareness**. Improved surveillance of proximate aircraft in the cockpit will improve pilot situational awareness. Presently, pilots must use visual scanning and acquisition and mentally maintain a picture of where aircraft are. For VFR pilots, traffic call-outs are provided by controllers, but on a work-permitting basis. A CDTI, integrated with other information in the cockpit will have multiplied benefits. See also section 4.4.2, which addressed benefits related to an overall cockpit information system (CIS) and integrated display of traffic, weather, terrain, and navigation data.

- **Increased surveillance coverage**. The ability to increase surveillance coverage without adding more ground based radars depends directly upon the aircraft's ability to accurately determine its location. ADS-B will take GPS positional information and broadcast this information to other nearby aircraft and to receivers on the ground. This provides aircraft location information to the ground without the expense of ground based radars. It also provides air-to-air surveillance capabilities which are not currently available to aircraft other than those equipped with TCAS. This benefit will be a major factor in improving air operations in remote areas, such as northern Alaska.

- **Increased airspace flexibility and accessibility through reduced separation minima**. Separation requirements are based upon many factors, one of which is the controller's knowledge of the aircraft's position. By providing the controller high accuracy GPS position information through ADS-B, some separation criteria, especially in the oceanic flight regime, may be reduced. Other improvements, such as satellite communications, higher accuracy altimeters, and modified air traffic control procedures, will also contribute to a reduction in separation requirements. Reducing separation minima will allow more aircraft to fly at their optimum altitude, speed and routing, again resulting in improved economic costs for the operator.

- **Dynamic rerouting, dynamic management of route structures, flexible tracks, optimum altitude, step climb, cruise climb**. These operational maneuvers depend on more accurate information about the aircraft's current position and future intentions. Accurate position information will be broadcast to the controller via ADS-B, adding surveillance coverage in areas where radar surveillance is not available. Benefits again will be savings in time, fuel and operating costs.

- **Improved airport safety through more accurate and reliable surface detection capabilities and display of surface traffic in the tower and in the aircraft**. With GPS tracking receivers placed on ground vehicles operating on the airport surface, LAAS will provide positional accuracies of less than 1 meter. Through broadcast of this positional information, ground controllers and pilots will be able to monitor positions of these vehicles. This benefit will be mainly to safety, as runway and taxiway incursions are reduced. Some operators may see an economic benefit as they better manage ground vehicles operating on the airport surfaces.

Additional operational improvements may be explored as part of the Tier III set of services and capabilities being evaluated within Flight 2000. Additional operational improvements to be considered based on ADS-B and CDTI include:

- **Lateral passing maneuvers in oceanic, en route, and remote non-radar airspace** These consist of co-altitude passing maneuvers by establishing an aircraft on an offset track, e.g., 15 nmi, passing another aircraft by the required minimum longitudinal separation, then rejoining the standard track. This would be a benefit to aircraft pairs when the in-trail aircraft's most efficient speed is substantially faster than the lead aircraft. This type of procedure may also allow a formal means for off-track passing of weather.

- **Station keeping** This is the monitoring of in-trail distance once a desired interval has been established. This has pilot workload implications and automation assistance (e.g., range alert) may be needed. In addition, stringent reliability and availability requirements will be levied. During station keeping in non-radar airspace, ATC could instruct the flight crew to maintain a specific distance from a lead aircraft (e.g., 20 nmi). The flight crew would use information derived from the traffic display to judge maneuvering of their aircraft to maintain the specified distance behind the lead aircraft. ATC may assign speeds to both aircraft to facilitate the maintenance of the specified distance. Initial implementations of this concept may be procedurally based, similar to the ITC/ITD, and not require a change in separation responsibility. This application would have substantial capacity and efficiency benefits. For oceanic operations longitudinal separation standards could effectively be reduced from the current time-based 10-15 minutes to a distance-based standard of 20 or 30 nmi facilitating increased efficiency, flexibility, and capacity. For non-radar airspace other than oceanic, this application could augment current distance-based separation procedures based on ground navigation equipment, area navigation capabilities, and current controller/pilot communications.

- **Reduced runway sepaartion for parallel approaches**. With apprpriate monitoring tools in the cockpit, pilots can execute parellel approaches (dependent or independent) at closer runway separations than feasible using the parellel runway monitor (PRM). Cockpit tools would be used to monitor the approach of the aircraft at the other runway. In the case the other aircraft is predicted to enter the non-incursion zone, the detecting aircraft could execute an escape maneuver. By reducing runway separation, improvements in overall airport

capacity and reductions in delays would be realized in conditions where VFR approaches are no longer acceptable.

4.2.5 Deployment Configuration

Two types of ground stations are planned for additional surveillance capabilities to support Flight 2000: A Mode S radar upgrade and ADS-B receiver sites. A Mode S upgrade will be implemented at Anchorage, Alaska.

Numerous ADS-B stations will be installed to receive aircraft broadcast transmissions and relay this information to control centers. Alaskan sites are planned for Anchorage, Bethel, Nome, Dillingham, Juneau, Dutch Harbor plus several remote sites added to fill in areas without radar coverage. For economy of installation and use of existing communications networks, these sites will be co-located with existing RCAG and RCO sites. Hawaii stations are planned at Lihue, Kahului, Kailua-Kona, Hoolehea and Hilo. Several surveillance gap filler ADS-B stations will also be placed in Hawaii.

Multilateration sites for Alaska are Anchorage, Dutch Harbor and Bethel; Honolulu is the sole site in Hawaii.

4.3 Controller-Pilot Data Link Communications

4.3.1 Functional Description

Controller-Pilot Data Link Communications (CPDLC) will enable air traffic controllers to communicate with aircraft crews by direct, addressed messages. Controllers will use FAA air traffic control automation to data link these messages to aircraft equipped to receive, display and respond to them. This message service is called Controller-Pilot Data Link Communications since its primary users will be FAA controllers on the ground and pilots in the aircraft. CPDLC will be used as appropriate, in conjunction with, and to augment existing voice radio communications. CPDLC has the speed and reliability to guarantee delivery of air traffic information and to ensure the safety of airspace users.

4.3.2 Benefits

The direct effect of Controller-Pilot Data Link Communications (CPDLC) is its ability to increase the capacity of the communications channel between controllers and pilots. When applied to en route airspace sectors currently affected by frequency congestion, studies have shown that by permitting more timely and effective control instructions, a communications system combining voice radio and CPDLC will reduce aircraft delays and increase operating efficiency.

Economic benefits that may be associated with CPDLC capabilities will be realized indirectly through changes in ATC capabilities and performance that are made possible by this technology. For this reason, the process of assessing these benefits begins by examining some problems which

exist in ATC communications, and the effects that the introduction of CPDLC can be expected to have on them.

FAA studies show that controllers can utilize the traditional voice channel along with CPDLC to effectively expand the capacity of the air-ground communications channel. In an en route operational evaluation, the provision of an initial service capability reduced the number of voice transmissions initiated by controllers up to 41 percent. It also reduced the total amount of time that the controllers occupied the radio frequencies up to 45 percent. Furthermore, as the proportion of aircraft equipped with Data Link was raised from 20 to 80 percent of the total number presented in the tests, the overall efficiency of ATC communications improved as requirements for repetitions of voice messages and clarification of misunderstood clearances decreased.

In addition to its potential for reducing communications-induced limitations on effective system capacity, analyses performed by the FAA have indicated that CPDLC can reduce the occurrence of common ATC communications errors that affect flight safety and efficiency. Incidence estimates available from a number of sources clearly show that communications problems are a major source of concern in the present ATC system. In 1988, the FAA noted that 23 percent of all operational errors (minimum aircraft separation violations) were caused either directly or indirectly by communications mistakes. Similarly, compilations of reports provided on a voluntary basis by aircrews and controllers to the Aviation Safety Reporting System (ASRS) have indicated that 70 to 80 percent of all potentially hazardous incidents that are reported implicate ineffective verbal information transfer; and that a clear majority of these involve air-ground radio communications.

Unlike voice radio, CPDLC offers a communications medium which transmits coded, digital data to individual addressees. CPDLC should improve message foundation by providing reasonableness and logic checks of the digital data. Message composition can be assisted by storing common messages for selection from a menu, and by employing automatic checks on controller inputs to prevent erroneous transmissions. Furthermore, message composition would not be impeded by the delays experienced when the radio channel is in use by pilots.

Message transmission also will be improved because CPDLC will assume some portion of the load on congested radio frequencies. This will not only increase the availability of the voice frequency, but also reduce controller workload and increase the timeliness of clearance delivery by permitting controllers to communicate when necessary -- not merely when the channel is available. In addition, those messages carried by data link will be effectively immune to degradation by noise and blocking, factors that plague an analogue radio system and impair pilot perception. Likewise, message interpretation will be enhanced because pilots will have a persistent, storable reference of message content, and because available evidence suggests that a visual display may be less prone to misinterpretation than an acoustic medium, even if voice synthesis is used to deliver data link messages to facilitate single pilot operations. Finally, the acknowledgment and verification stage of the communications process, which is a human responsibility in the voice radio system, will be largely allocated to the CPDLC system.

ASRS safety data collected between 1980-1984 included 2,700 reports of communications problems. Analysis of this data indicate that CPDLC would produce a major reduction in communications problems that form 45 percent of all reported communications incidents. A further 54 percent of incidents would be at least partially reduced by CPDLC. Only 1 percent of all problems would be unaffected, these being situations where the controller issues a logically reasonable, but erroneous clearance because of faulty decision making.
The direct effects of CPDLC include reducing voice channel congestion, freeing the controller to be more efficient and productive with his or her time, and increasing safety by improving the accuracy of pilot and controller communications.

4.3.3 Deployment Configuration

The Flight 2000 CPDLC system will be implemented as an enhancement to the existing FAA automation at the Oakland air traffic control center (ARTCC). The CPDLC system will be used by Oakland ARTCC based controllers who manage the Oakland en route airspace, and the transition airspace between Oakland en route airspace and the oceanic airspace over the Pacific Ocean.

The Flight 2000 CPDLC system will communicate with aircraft equipped with FANS avionics, which is commercially available, and already on many aircraft that fly in Pacific oceanic airspace. The Flight 2000 CPDLC will also communicate with ATN avionics when they are introduced

There are several components to the Flight 2000 CPDLC system. At the Oakland ARTCC, software enhancements will be made to the Host Computer System (HCS), which provides the controllers with radar data, flight plans, aircraft position and identification, and provides tools to assist the controller monitor and control the progress of aircraft. These software enhancements will automate the controller-to-pilot text message communication, by providing point-and-click aircraft selection, menus of often-used messages, and automatic error-checking. The Host will drive the Display System Replacement (DSR) consoles, which will present the CPDLC enhancements in addition to the existing air traffic control data blocks, status lists, and other displays.

The Host will be connected to another, new computer, known as the Data Link Applications Processor, or DLAP. The DLAP, with custom software, will keep track of the communications links with each aircraft, and ensure that each message sent from the controller, via the Host, reaches the correct aircraft. The DLAP will be tied to the Host via the Host's new Fiber Optic Local Area Network (HID/NAS LAN). The DLAP will also be connected, via the FAA's existing NAS data interchange wide area network, NADIN II, to the commercial service provider who will actually radio the digital text message to the aircraft's avionics. A gateway will be installed allowing messages and responses to go back and forth between the FAA's ground network and the commercial service provider's system, while ensuring the highest level of security and integrity.

Once received, the FANS avionics will alert the crew that a message was received, and will display it for review. Depending upon the message, options will be presented to reply, either as a

Roger, Wilco, or Unable. The pilot interface will depend upon the particular FANS installation package of the airline. Once reviewed, the pilot's response will be down-linked back to the commercial service provider, who will forward it to the Oakland ARTCC, where the DLAP will route the reply, via the Host, back to the appropriate controller. The entire controller-to-pilot data link communication process will be governed by amendments to the procedures used today, developed especially to deal with all possible circumstances created by this new tool.

This system architecture gives the FAA considerable flexibility in fulfilling the CPDLC mission. For example, as the message formats are enhanced, most of the changes can be accommodated by modifying the modern software coded into the DLAP, rather than the more complex Host software. This will also be the case when the FAA transitions to the latest CPDLC formats contained within the International Civil Aviation Organization's upcoming Aeronautical Telecommunications Network standards, commonly referred to as the ICAO ATN SARPS. When technology insertion and natural computer lifecycles demand replacement of the existing Host, only a portion of the CPDLC system will require porting to the Host Replacement.

The CPDLC system, as a software and hardware enhancement to the Oakland ARTCC Host, will be maintained and operated by the on-site Host Airway Facilities staff, whose present expertise will be augmented by CPDLC-specific training.

4.4 Flight Information Services (Fis) In The Cockpit

Previous sections have described aircraft navigation, air-to-air and air-to-ground surveillance, and controller-pilot data link communications capabilities that provide important information to the cockpit. This section describes additional Flight Information Services (FIS) and the Cockpit Information System (CIS) needed to improve further situational awareness in the cockpit and to facilitate safe, efficient, flexible aircraft operations.

4.4.1 Functional Description

The two principal enabling technologies for cost-effective integration and implementation of advanced cockpit avionics are the multi-mode, multi-band radio and an avionics computer resource (ACR), both undergoing development. The functional architecture of such a Cockpit Information System (CIS) is depicted in Figure 4.4-1.

The CIS provides situational awareness and other related data to the cockpit and allows for pilot input for data communications and system control. Situational awareness includes location, weather, traffic, SUA/NOTAMs, and obstruction and terrain information. Related information includes ATS/AOC communications and navigation information. Some or all of these functions will be provided in Flight 2000 depending on user class, phase of flight, and the availability of ground and communication support services to provide the data. For some user configurations an integrated multifunction display will be used. The following functional characteristics are applicable:

Planning -- Depending on the class of the user, the CIS is capable of accepting flight crew or FMS inputs associated with route planning and waypoints for preferred routes. The CIS is capable of delivering the route request, via data link, to the ATS provider and receiving a reply. Route requests may be a function of the weather and Special Use Airspace (SUA) information.

Weather Information -- The CIS displays weather data in text, graphics, or aurally, depending on the nature of the information and the class of user. Weather information may come via data link from a data base on the ground or from other aircraft. The CIS may send its own weather information via data link, when appropriate. CIS weather advisories/alerts may be given aurally.

SUA Information -- The CIS displays SUA status and related information in text or graphics, as appropriate. The SUA information may be previously stored or may be updated in real time. CIS generated SUA advisories/alerts may also be presented aurally.

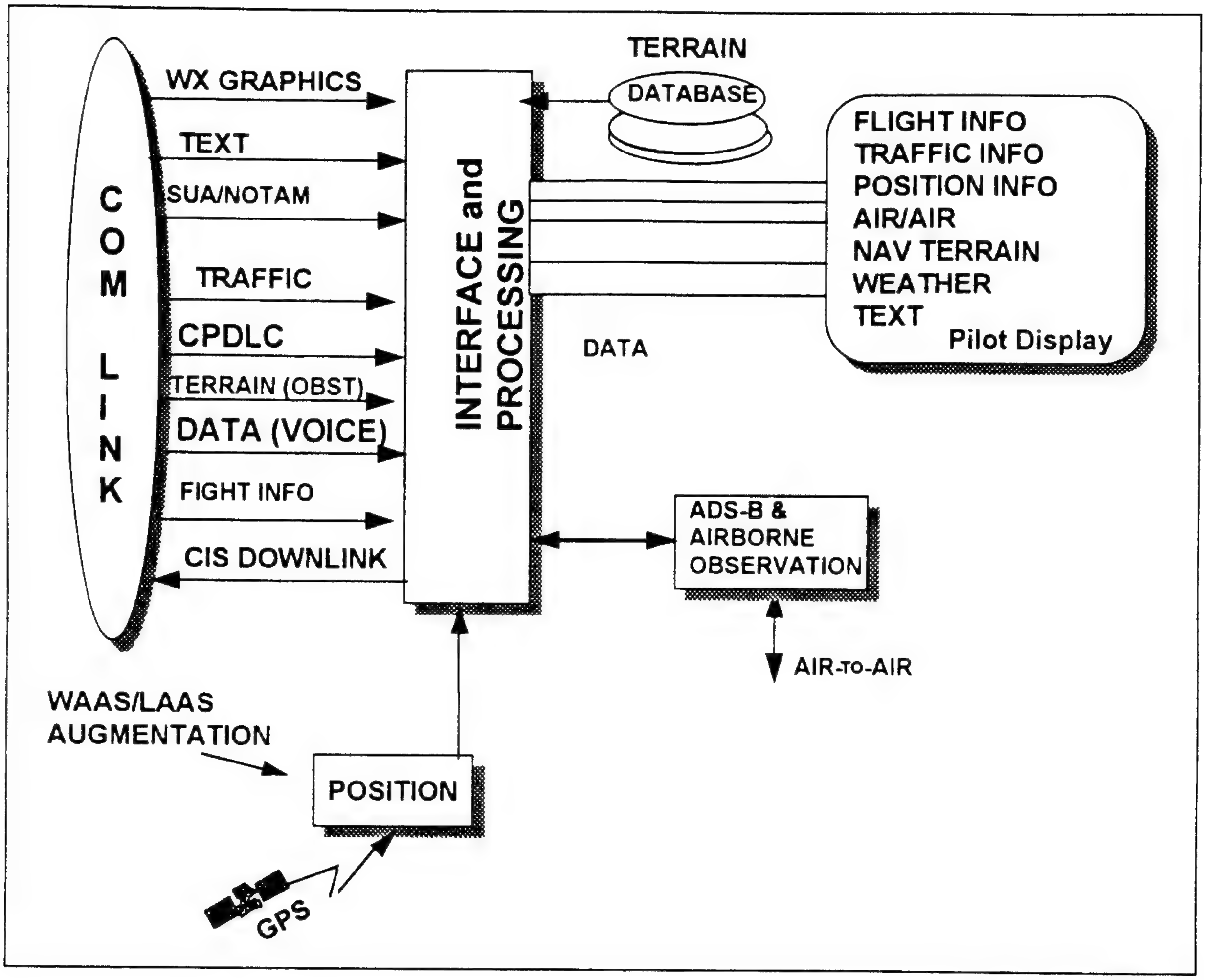


Figure 4.4-1.
CIS Architecture

Notices to Airmen (NOTAMs) -- The text of available NOTAMs involving navigation aid status, weather, and other significant data will be displayed in the cockpit when provided via data link by a flight information service server on the ground.

Digital Airport Terminal Information Service (D-ATIS) -- D-ATIS information, including airport altimeter setting, runways in use, local weather, navigation aid status, and other relevant airport information will also be displayed when provided via data link by equipped D-ATIS ground facilities.

Situational Awareness Data -- To augment the "see and avoid" capability in the cockpit, terrain/obstacle, weather, and traffic information are displayed by the CIS. Weather information will be from broadcasts or requested via data link by the pilot. Traffic information will be transmitted from the ground or gathered onboard the aircraft via air-to-air surveillance (ADS-B).

Navigation and Traffic Information -- The CIS may provide a moving map display that indicates own position along with traffic, NAVAID, and other facility information. This display will facilitate stationkeeping if required. The CIS can display surface and taxiway maps with own and other traffic indicated. The CIS may alert the cockpit if a hazardous situation develops.

ATC Communications -- The CIS displays selected ATC clearances and instructions sent via data link. The CIS may have an interface that allows the pilot to reply to ATC by data link. The CIS may have an interface with the FMS/FMC that permits new clearances to be input with less pilot workload.

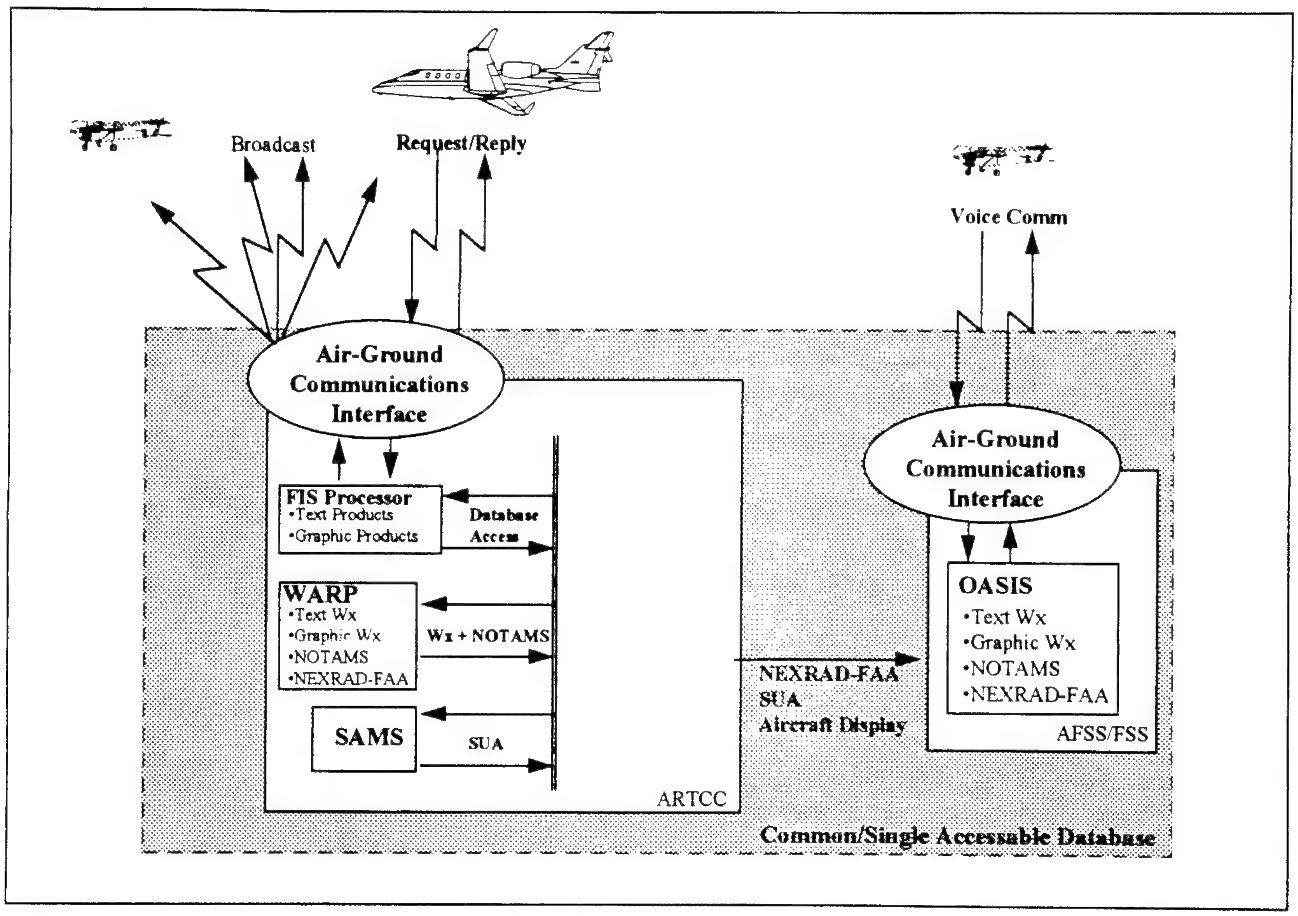


Figure 4.4-2.
FIS Infrastructure

Weather Services -- One of the functional requirements for Flight 2000 aircraft is presenting near real-time weather to the pilot during flight. Using this capability, pilots can reroute around severe hazards by overlaying their flight path on top of the weather. Making flight plan changes while en route will promote safety.

To provide parity in FIS information, common, accessible databases will be used to develop cockpit weather and FIS products, and to support the ARTCC controllers and AFSS/FSS specialists as depicted in Figure 4.4-2. A major source of graphical weather will be products based on information from the NEXRAD weather radar sites operated by the National Weather Service (NWS), the Department of Defense and the FAA. The FAA operates seven NEXRAD radars in Alaska and four in Hawaii. The FAA Weather and Radar Processor (WARP) program will be the Flight 2000 and NAS source for NEXRAD products for Alaska and the Continental United States. The NEXRAD database source for Hawaii is yet to be determined.

With the exception of a provision for pilot requests for specific weather information, weather data will be provided by the FAA to Flight 2000 aircraft via VDL Mode 2. Using the same VHF signal in space as VDL Mode 2, there would be sufficient capacity to broadcast more than 30 graphical weather maps every five minutes over a dedicated channel. This is an enormous increase in functionality while using a common radio. Broadcast communications eliminates the use of two-way frequencies for repetitive information and provides a large increase in effective data throughput providing future capabilities. Each broadcast will provide graphical weather data over a range of at least a regional area plus a national picture. Text weather for all reporting airports will also be broadcast, with similar area coverage. Most of this data will most likely not be presented to the pilot except by request of the pilot to the on-board system.

The total amount of weather data transmitted over the broadcast data link could be fairly large even with graphical data compression techniques. For example, a compressed NEXRAD presentation (national map coverage) requires typically 10K bytes of data. Similarly, a terminal forecast (text) covering a 200-NM radius is estimated to require less than 3K bytes, and several different types of text report may be desired over the same area. The saving feature is that most of these reports will not be updated very frequently; a typical update rate would be 5 minutes worst-case for enroute support. The VDL Mode 2 broadcast mode at 31.5 kbps could easily support a total weather database on the aircraft.

Broadcast of Text Messages -- There are sets of messages now broadcast by recorded or digitized voice, or are textual but not in plain English. They include ATIS, NOTAMs, and SIGMETS. Present ATIS is the continuous broadcast of voice recorded, non-control information in selected high activity terminal areas. Its purpose is to relieve controller work load and frequency congestion by broadcasting repetitive but considered essential information. ATIS presently provides present barometric setting, local wind conditions, active runways, etc. D-ATIS will be the digital, textual equivalent of the present service. D-ATIS as well as NOTAMs, and SIGMETS transmissions could be decoded in plain English by the Cockpit Information System (CIS) and include observations of ceiling, visibility, obstructions to visibility, temperature and dew point, wind direction and velocity, altimeter, instrument approach, runway in use, and other remarks.

ATIS is expected to transition from the voice recorded system to the digital implementation in the VHF band channels presently used. This will expand on the current D-ATIS communications architecture which relys on ARINC for databasing and ACARS for data link access. The link is expected to broadcast this data using VDL Mode 2 and will provide aircraft data link access to D-

ATIS while within line-of-sight (LOS) of the ground transmitter site. Using the same avionics as for ATC two-way data messaging allows for common avionics to provide additional capability without additional cost.

E-PIREPs -- Presently pilots are encouraged to provide pilot reports when the weather is poor, e.g., icing conditions, thunderstorms in the area, etc. ARTCCs or Flight Service Stations are usually contacted and given airborne information related to local weather.

Flight 2000 aircraft equipped with additional sensors for turbulence, icing, dew point, etc., could automatically report usable weather data without pilot intervention. A draft MOPS has been developed by RTCA SC-169, Working Group 3 specifying the reporting parameters for various categories of aircraft-derived meteorological reports such as E-PIREPs. If the standards are developed and sufficient reports generated by participating aircraft, ground receipt and databasing of these reports may be attempted as a test objective for Flight 2000. Air-air transmission of E-PIREPS may be evaluated as a Tier III service.

4.4.2 FIS Benefits

The principal benefit of the Flight Information Services provided to the Flight 2000 Cockpit Information System is enhanced situational awareness that results ultimately in improved operational safety. The FIS information is intended mainly to help pilots avoid hazardous weather, controlled flight into terrain, restricted airspace, and other aircraft. The secondary operational benefit of FIS is reduced delays, and the associated time and fuel penalties, that result from the improved planning and more direct routes made possible by current and accurate traffic, environmental, terrain, and NAS resource information.

Specific operational improvements associated with the implementation of CIS are as follows:

- Safety is enhanced by providing better traffic information and aircraft proximity advisories, enhanced visual acquisition of other traffic, thus improving "see and avoid." Also, cockpit weather is a key priority and mitigating strategy for reducing weather related accidents, especially for general aviation, by assisting in hazardous weather avoidance.

- On the airport surface, taxi delays will be reduced through improved awareness of aircraft positions. Runway incursions and accidents at non-towered airports will be reduced. Efficiency of aircraft movements on the airport will be enhanced.

- Free flight and increased situational awareness will be facilitated by accurate cockpit-based surveillance technology in combination with improved access to weather, flight information, NOTAMS, SUA status, navigation, and terrain information. An integrated display of these elements will enhance a pilot's understanding of both the tactical and strategic conditions affecting the flight. Specific operational improvements are anticipated by using the display of traffic information as an element of separation procedures (see 4.2.4).

- Safety benefits include the reduction of potential mid-air or near mid-air collisions, avoidance of CFIT, reduced intrusions into protected airspace and reduced accidents or incidents due to severe weather.

4.4.3 Deployment Configuration

An FIS processor/server (see Figure 4.4-2) will be provided at Anchorage ARTCC and Honolulu CERAP (or AFSS based on site survey) to collect, process, and distribute FIS data to a wide range of aircraft within Alaska and Hawaii. The Flight 2000 operational environment involves general aviation aircraft for personal and business use, air taxis, commuter aircraft, air carriers, military aircraft, helicopters, and non-powered aircraft. There will be a diverse mix of these aircraft in Alaska and Hawaii, as well as widely-varying levels of traffic and mixes of equipage (including unequipped aircraft) in both regions. Specific operational characteristics are described in the following paragraphs.

Alaska -- Air transportation is the primary means used to move people and cargo over long distances. Pilots feel increased pressure to fly under sub-optimal conditions due to the perceived critical nature of the aircraft payloads. Several large bands of mountains cross the state, creating rapid weather changes. It is not uncommon for weather to change from VFR to IFR with icing in a matter of minutes. Most aircraft are single-engine airplanes hauling heavy loads of people and cargo. Due to performance limitations and high terrain, pilots must fly through mountain passes and other places where lateral terrain clearance is minimal. Communications, navigation, and surveillance radar are limited to areas of VHF communications and radar coverage. Due to the line-of-sight nature of these signals, and the mountain ranges that block them, there are large geographic voids where pilots cannot receive the needed services. Areas of special use airspace cover wide areas of the state, further complicating visual and non-visual separation of aircraft.

Hawaii -- The operational environment in Hawaii is characterized by a mix of in-bound traffic from the West Coast and foreign countries, domestic traffic, heavy tourist activity, sudden changes in weather (including volcanic ash and thunderstorms), terrain concerns for small general aviation aircraft at low altitude, SUA, and heavy ATC communications. Island traffic can complicate traffic flows because of limited communication within the islands, and the complexity of clearances. Highly organized inbound traffic from the oceanic track system is interrupted by "island hopping" aircraft and aircraft flying random routes. Some aircraft transition from domestic separation standards to oceanic separation. In addition, there are many aerial refueling tracks in the area.

4.5 Decision Support Systems

This section describes the capabilities, benefits, and deployment of the decision support tools to be evaluated during the Flight 2000 program.

4.5.1 Functional Description

4.5.1.1 Enhanced Oceanic Conflict Probe

Flight 2000 will incorporate a test bed for evaluating the proposed approach for improving separation services and flexibility in the Oceanic Airspace. This approach is based on development of an enhanced oceanic conflict probe capability.

During the trials one controller will maintain flight strip accuracy, while a second controller will be brought into the sector to operate a shadow operation from the secondary display. The shadow controller time will be shared between 1) responding to events, and 2) monitoring the flow.

The controller will manage exceptions to the flow plan as events, to include progress reports that are out of conformance or late, pilot requests for altitude or route changes, flight plan activations, and incoming and outgoing coordination messages. The controller will be notified of these exception events through textual and graphical indications. With this change from today's procedures, the caseload of events that require controller action will shrink from today's caseload. The controller will have more time to monitor the flow picture, re-verify the separation picture, and plan for user requests.

The controller will monitor the flow picture using a graphical depiction of routes, fixes, aircraft locations and direction, and airspace boundaries. The controller will not be required to routinely read the position reports, instead when pilot estimates differ from the computer estimated fix crossing times, both times are presented to the controller. The conflict probe tool will provide the controller with graphically and textually description of head-on, lateral, longitudinal, crossing and convergence/divergence conflicts. The controller will determine the feasibility of the flight plan using all the data available, and will take action to modify the flight plan as necessary to meet planning needs and separation assurance. The controller will be able to modify the flight plan or will be able to contact the sector with executive control and request flight plan changes. The controller will also be able to annotate the flight for corrective action to be taken at a later time. The controller will also use tables of flight data to monitor the flow and separation picture. In addition to flow monitoring, the controller will use the aircraft table and fix tables to verify separation between aircraft and to plan for user requests. The conflict probe tool will perform trial probes as well as probes when aircraft report not as expected.

The controller will also plan for pending flights. Prior to an aircraft being activated, the controller will be able to project fix crossing times for pending aircraft based on the estimated boundary crossing times for the pending aircraft and on the actual flight progress of active aircraft using the same route of flight. Once activated, estimated flight progress will be available to the controller on the aircraft table and fix tables.

Subsystem components comprising the evaluation include the active automation system and staff and the evaluation system. The high level functional allocation to each automation and staff component are as follows:

Oceanic Display and Planning System (ODAPS) with Oceanic Data Link (ODL)

- print flight strips
- exchange air/ground messages
- exchange interfacility messages

Evaluation System

- identify & graphically depict conflicts
- identify position reports by exception
- provide tables for identifying conflicts & resolutions

Evaluation System Controller

- determine separation criteria between aircraft pairs
- plan for entry of new aircraft

Oceanic Controller (s)

- maintain the ODAPS data base as current
- maintain the flight strip data
- address air-ground requests

The high level functional allocation presented above is further decomposed and presented here by subsystem component:

ODAPS with ODL

In addition to the current functional capabilities as described in Functional Description for the Oceanic Data Link, the Communications Server shall:

- parse the flight plan data and air/ground messages to forward changes in position or flight plan to the evaluation system

- incorporate climb profiles into the flight plan data base (beyond 2000)

<u>Evaluation System</u>

The evaluation system shall:

- test each flight plan change for procedural conflicts with other flights
- test each proposed flight plan for procedural conflicts with other flights
- indicate each position report which contains data other than what was expected (format, conformance, overdue, requests, free text)
- incorporate clearances & instructions into the trial probes
- test each non-conformance for procedural conflicts with other flights
- depict each potential conflict (the routes, time of conflict, and type of conflict)
- graphically depict each route and times over waypoints on request
- allow the controller to annotate each conflict with actions to be taken or that have been taken
- provide a list of aircraft that are under the sector's control including current location, status, route of flight, and near term intent
- Check FIR boundary conditions and other constraints (beyond 2000)
- Incorporate each flights step climb plan when conducting the probe (beyond 2000)

The following performance characteristics apply to the overall performance of the automation and human components of the system:

- Probes must handle 300 aircraft with a trial probe response time of < 10 seconds.
- Procedural probe must have 0 missed alerts with false alarms being primarily driven by errors inherent within position reports.
- No more than 10% of the position reports should require controller review.
- All single message instructions from DO-212 should be incorporated in the flight plan data for the purposes of probe.

4.5.2 Benefits

4.5.2.1 Enhanced Oceanic Conflict Probe

The operational benefit anticipated from this initiative is the increased likelihood of granting user-preferred profiles by judiciously applying separation standards. This step will provide fuel and time savings to the user by freeing controller time to address user requests.
Once confidence is gained in the procedures and automation, the following free flight procedures would be possible:

- free routing in more dense airspace, and
- collaborative resolution of conflicts

4.5.3 Deployment Configuration

4.5.3.1 Enhanced Oceanic Conflict Probe

The proposed decision support tools initiative will require modifications to the Oakland Center ODL and creation of the prototype for evaluation. The modifications to the ODL will be required to support the early stages of the Oceanic Flight 2000 initiative. The acquisition activity will begin in early 1998 to permit completion of training, site implementation, and familiarization prior to the end of the year. The current Oceanic System Development and Support (OSDS) contract, which contains the options for enhanced conflict probe to support the Flight 2000 initiative, is a likely candidate for acquisition of this capability.

Figure 4.5-4 shows the data flow among the automation components of the ATM system supporting the procedural separation support tool initiative.

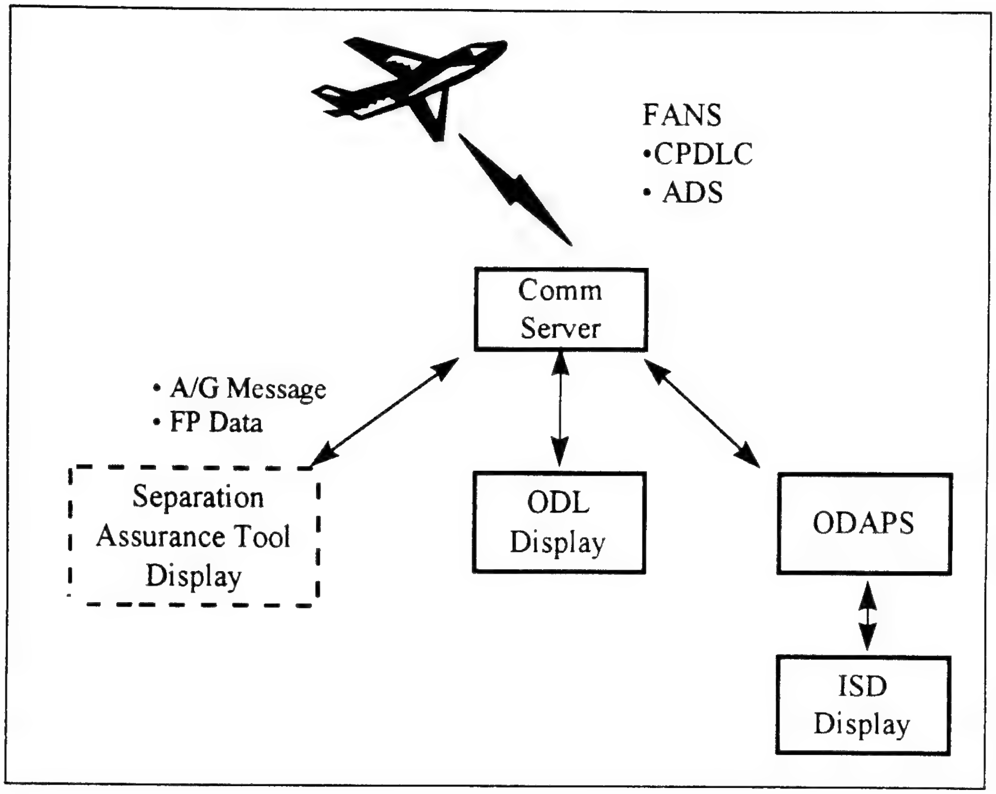


Figure 4.5-4.

Data Flow Among Automation Components for Oceanic Procedural Separation Support Tools

5.0 Certification Implementation

5.1 Introduction

Certification is a prime component of Flight 2000 and successful evolution to the air traffic management system of the 21st century. Certification activities for Flight 2000 will ensure that enabling technologies and associated operational procedures will continue to meet stringent FAA safety requirements, while reducing time and costs for approval. Since Flight 2000 is an operational demonstration, aircraft avionics suites, flight procedures, ground communications networks, and operational specifications will require FAA approval.

The FAA will streamline its certification procedures. Planned improvements respond to industry concerns that traditional methods are overly time consuming and expensive both for the applicant and the Government. Improvement in the certification process will serve the needs of all Government and industry participants, and is one of the major objectives of Flight 2000. Close collaboration on the development of certification standards and implementation of the procedures will be required for any substantial enhancement in the process. The impact of a streamlined certification process will continue far beyond Flight 2000 and will be critical in transitioning new technologies and operational procedures to the NAS of the future.

5.2 Aircraft Certification

Current avionics technologies are evolving rapidly. We expect the avionics suites proposed for Flight 2000 to be available for scheduled implementation. Even without Flight 2000, the FAA will face certification challenges to meet global marketing demands. Flight 2000 will provide an opportunity to prototype a streamlined process that improves overall safety and provides cost savings. The following improvements will be made.

1. **Certification policy will be standardized.** The streamlining effort will assure that certification policy is standardized. A team of FAA certification engineers, including flight test personnel, will be formed to focus exclusively on Flight 2000 certification issues. The team will be managed centrally by Washington headquarters to ensure that certification policies are standardized throughout the required aircraft certification activities. Additional funding and personnel will be required to eliminate existing backlogs, and allow coordination and planning of the Flight 2000 certification process to being immediately.

2. **In partnership with the industry, choke points in existing certification processes will be identified.** Reductions in the size of complexity of RTCA Minimum Operational Performance Standards (MOPS) and Minimum Acceptable System Performance Standards (MASPS) will reduce the time and cost of the certification process. FAA certification personnel will work with RTCA to ensure that applicable requirements for Flight 2000 are true minimum requirements. Standards development will be expedited by focusing RTCA on standards activities needed to complete Flight 2000.

3. **The system integrator will develop automated tools to track requirements documents in MASPS, MOPS, and Technical Standard Orders (TSO).** Only the highest level of requirements and testing will be applied to avoid redundant and excessive testing. Simulation rather than flight testing will be used whenever possible to decrease certification costs.

4. **The Flight 2000 certification team will review applicable certification policies and requirements (FARs and CARs) to validate current policies and standards and identify needed changes.** New guidance will be prepared and disseminated as needed. The process developed must ensure an acceptable level of safety while facilitating installation of equipment in time for the Flight 2000 demonstration.

5.3 Operational Certification

FAA's Flight Standard Service will conduct a review of approval standards for air carriers, commercial operators,, agencies and airmen as part of Flight 2000. This review will cover all aspects of the approval process for airmen and operators, both commercial and general aviation. In addition, new routes and instruments approaches will be developed to meet the requirement for direct routing, taking advantage of GPS navigation capabilities. Flight Standards personnel will also review carefully airmen certification requirements and associated training programs developed for the new technologies in Flight 2000 to guarantee safety and efficiency.

Procedures

The Flight Standards Service is responsible for setting policy, guidance, and criteria for use of Flight 2000 systems. There will likely be new references for Communication, Navigation, and Surveillance performance standards where current standards are lacking. The approval process will extend to facility approvals, airmen certification, maintenance, and equipage requirements.

Training to enable operators to carry out the requirements of the system will be established.

Airmen Approvals

The introduction of new technologies and operating procedures require approved training programs to prepare operators for enhanced capabilities and to ensure their proficiency. All operators and levels of operation will be affected.

Maintenance Requirements

Maintenance programs will be reviewed in consideration of new systems performance capabilities relative to existing standards. If system performance exceeds current requirements, there may be opportunities to reduce life cycle costs. Flight 2000 will provide an opportunity to identify enhanced performance characteristics and allow appropriate credit for these improvements.

5.4 Systems Approval

To improve the new technology implementation process within the FAA, Flight 2000 will approach ground and airborne certification as a single system with integrated requirements.

Flight 2000 architecture reflects a systems approach to develop functional, performance, and integrity requirements for new technologies and applications. New operational procedures, combined with a certified and integrated air and ground infrastructure, will be operationally evaluated. Certification of required systems will occur either before or during the two year operational evaluation period which starts in September, 2000. With successful operational evaluation completed, certified systems will be determined ready for transitioning for additional locations in the United States.

The three major components of Flight 2000, airborne avionics, and ground systems, including surveillance, will be considered as an integrated whole by focusing on the "end-to-end" capabilities of the components. As an example of the "end-to-end" certification focus is the interface requirements and performance capabilities of communication flow between aircraft, the ground, and the space segment. To be successful, this approach will be carried out by teams made up of specialist from each primary line of business.

Flight 2000 must assure that required information is presented to both pilot and controller in a timely manner. The system approach to satisfying these requirements relies on careful interface requirements specification.

Flight 2000 encompasses large air transports down to small general aviation aircraft, and wide variations in avionics capabilities. By limiting the number of avionics configurations and types of aircraft into which the avionics will be installed, certification risks and costs can be controlled. Selection of aircraft will focus on minimizing avionics configurations, thus reducing the variations in supplemental type certificates required for installation.

6.0 Program Management

6.1 Concept

The Flight 2000 Program is an integrated Government/Industry effort to demonstrate and validate advanced aviation technology and operational concepts. As a path to Free Flight, this program represents a key step in accomplishing the expedited modernization of the NAS by 2005. Successfully completing such a demanding effort will require comprehensive program management that includes a broad range of organizations and individuals, and addresses issues in a timely and forthright manner. Clearly this initiative is not "business as usual," but demands an advanced management approach comparable to the technology it promotes.

Flight 2000 is not a typical development effort, but rather an integrated demonstration and validation of capabilities program building upon the work of many other programs, bringing together products to function in concert in a real-world operational environment. Flight 2000 program management is based upon an Integrated Product Development System (IPDS) model, modified to account for the unique aspects of the program. The principal features of the IPDS model focus on: collective responsibility for desired outcomes, intense integrated initial planning to ensure quality products that satisfy customer needs, open communications, decision-making at the lowest level possible commensurate with risk, partnerships built upon trust and confidence, and performance measures which include both process and products with focus on customer satisfaction.

In place of a large program office normally associated with an effort of this magnitude, Flight 2000 will rely on a lean organizational array consisting of a small dedicated core team in FAA headquarters, a coordination team matrixed from each of the involved FAA organizations, and a small steering group regularly providing review and direction of the program. This approach is flexible enough to maneuver as necessary to successfully achieve the desired objectives, and at the same time inclusive of the many organizations needed to achieve the best answers and acceptance for follow-on transition of Flight 2000 technology to the entire NAS.

Organization

Flight 2000 Program Director - Reports directly to the Associate Administrators for Research and Acquisitions (ARA), Air Traffic Services (ATS), and Regulation and Certification (AVR), who will provide executive direction and broad policy guidance. The program director is responsible for operational and system evaluation of Flight 2000 as it relates to Free Flight architecture, concept of operations, and subsystems. Under the Program Director's guidance, Flight 2000 will result in a demonstration/validation of new aviation operational concepts and capabilities in Alaska, Hawaii, and other selected locations. The program director is assisted by the core team on a day-to-day basis.

Flight 2000 Steering Group - Reports to the program director and provides recommendations and proposes guidance to ensure that the validation effort remains integrated with the current focus of the Government/Industry Free Flight Steering Committee and its Select Committee for

Implementation. In order to coordinate this activity fully within the agency, the Steering Group consists of a top management level representative from ATS, AVR, ARA, NASA, and two industry representatives from the Select Committee for Implementation. The Steering Group will direct and coordinate the collaborative effort, leveraging the momentum of the Government and Industry Free Flight Steering Committee and appropriate existing Government and industry programs in a coherent manner.

Flight 2000 Coordination Team - Reports directly to the program director. It consists of key management personnel from each of the critical elements of current programs and activities that need to be integrated into the demonstration/validation effort. It will assure that all required coordination is undertaken and issues resolved to successfully carry out the Flight 2000 Implementation Plan. The Coordination Team consists of members from the following organizations: Alaska Region (AAL), Western-Pacific Region (AWP), Air Traffic Service (AAT), Air Traffic Requirements (ARS), Airways Facilities (AAF), Aircraft Certification (AIR), Flight Standards (AFS), Aviation Research (AAR), NAS Development (AND), System Architecture and Investment Analysis (ASD), Air Traffic Systems Development (AUA), System Safety (ASY), Airports (ARP), General Counsel (AGC) NASA and the DoD. Other internal organizations will be added as the need arises.

Flight 2000, since it will build upon the existing functional structure, will use the FAA's existing program monitoring functions as much as possible. The intent is to minimize the burden of additional reporting and instead to use processes like the Major Acquisition Review to assure that Flight 2000 activities are highlighted as major milestones within each program area. This approach assures that the Flight 2000 activities are fully integrated into each programs' overall goals contributing to NAS modernization.

Communication

A communications plan for Flight 2000 has been developed to assure the free flow of important information among the many diverse organizations and individuals essential to the success of the program. Principal communication objectives are to:

- establish a centralized, coordinated information effort that represents the FAA's position and implementation strategy on Flight 2000, supports the Flight 2000 Virtual Program office, and presents a consistent, timely, and accurate description of Flight 2000 activities.

- present information in terms of a demonstration/validation of the Free Flight concept, as a key component of the NAS modernization by 2005, and as a real-time industry/government collaboration.

Communication activities for Flight 2000 are proposed, developed, and coordinated by an interagency communications working group, with members from FAA major lines of business and the Flight 2000 core team. The Flight 2000 Program Director serves as principal spokesperson. Designated members of the Flight 2000 Steering Group, Core Team, and Coordinating Team serve as spokespersons for Flight 2000.

A variety of communications methods will be employed including regularly scheduled meetings, FAA Flight 2000 website, fact sheets, articles, and press briefings.

7.0 Schedule And Cost

Flight 2000 begins the transition of the nation's air transportation system into the free flight era. The schedule emphasis is to provide reliable new service capabilities as early as possible. This will allow lessons learned from Flight 2000 to shape the NAS wide implementation of these Flight 2000 services.

Costs presented in this section were obtained from the technical teams who will develop, procure and implement the Flight 2000 services. They represent the additional funding FAA requires to accomplish the described program. Flight 2000 costs (totaling approximately $23 M) that can be supported within the present FAA appropriations and budget request levels, were not included in these cost estimate totals.

Individual cost and schedule elements of Flight 2000 have been grouped into six categories:

- Avionics - tasks and expenditures required to equip aircraft with Flight 2000 functionality
- Ground Systems Development - tasks and expenditures required to bring a system from prototype to a hardened system/equipment which successfully completes FAA operational testing
- Alaska Sites - includes unit cost of equipment/system and date of delivery to Alaska, installation, operation and support procedure development, and on-site training
- Hawaii Sites - same program elements as Alaska Sites
- Oakland ARTCC - same program elements as Alaska Sites
- Program Engineering and Evaluation - includes assessment of present FAA services, modeling and simulation of new technical and procedural approaches to air traffic services, evaluations of Flight 2000 services, and program wide management activities

Figure 7.0.1 displays, at the category level, schedules for accomplishing the Flight 2000 Program. Assuming full funding for Flight 2000 in FY1998, it is projected that all aircraft (2000) will be equipped with the required avionics suite by the Tier I date of September 30, 2000. A majority of the ground systems development and operational testing will be complete by January 2000, with those required for Alaska, Hawaii, and Oakland ARTCC Tier I Operational Services being installed and operating also by the Tier I date.

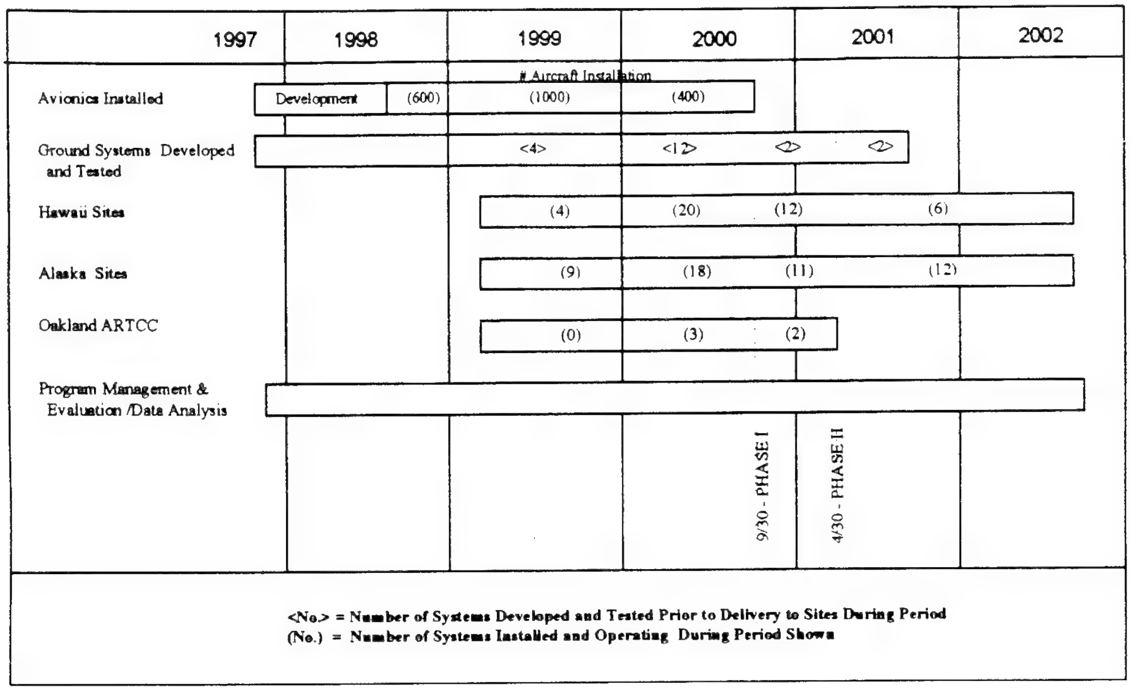


Figure 7.0.1
Program Summary

Table 7.0.1 is a summary of Flight 2000 costs and is presented in terms of the same six categories and by fiscal year.

The avionics cost includes estimated manufacturer's "off the shelf" price for a production of 2000 avionics suites, engineering costs for installing and certifying the avionics for participating aircraft, and the installation shop costs for each aircraft. The cost estimate assumes these units will be the initial buy for these avionics and will bear most of the manufacturer's development burden.

Personnel costs for FAA management, technical, and administrative staffing (41) required to accomplish Flight 2000 have been included within the six cost categories. The major component of the Post Evaluation/Maintenance Costs cost estimate is the need for additional air traffic controller personnel (34) resulting from the FAA providing new ADS-B based advisory and separation services in areas of Alaska and Hawaii that presently do not have these services. All costs for Flight 2000 operations and maintenance support incurred in preparation for and during the Flight 2000 Ops Evaluation have been included with the program's site costs (Hawaii, Alaska, and Oakland). Cost estimate of post evaluation operation and support of the in-place Flight 2000 infrastructure has been included as a separate line entry in Table 7.0.1.

Each of the following category subsections provides a more detail description of the cost and schedule elements that comprise that category.

Flight 2000 Cost Summary
(Dollars In Thousands)

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Avionics	62,200	82,500	25,700						170,400
Ground Systems Development	45,804	31,542	12,345	13,317	7,482				110,490
Acquisition/Installation of Ground Infrastructure	2,600	17,853	21,733	2,024	95				44,305
Engineering Evaluation	17,180	12,522	6,696	5,053	4,701				46,152
Flight 2000 Program Total	127,784	144,417	66,474	20,394	12,278				371,347
Operations/Maintenance of Ground Systems	2,080	4,148	5,896	6,100	0				18,224
Total Program	129,864	148,565	72,370	26,494	12,278				389,571

Table 7.0.1

7.1 Avionics

The Flight 2000 plan calls for equipping a minimum of 2000 aircraft, at government expense, with the advanced avionics equipment necessary to achieve the desired level of functionality. The purpose of this subsection is to estimate the funding required to purchase and install that equipment.

The standard Flight 2000 avionics package would be an integrated cockpit system consisting of five functional modules.

- **Communications.** A data-link radio capable of VDL Mode-2 (CSMA data only), upgradable to VDL Mode-3 (TDMA data/digital voice.)
- **Navigation.** Typically, a WAAS capable GPS system, certified for IFR en route and non-precision approach.
- **Surveillance.** Typically, Mode S transponder with ADS-B squitter capability.
- **Cockpit Information System.** Integration, processing, & routing of data for display and transmission.
- **Display.** Typically a color display measuring 5 or more inches diagonally.

These modules may be packaged as individual components or combined into integrated multi-function components.

Assumptions:
Only those technologies that are currently available, or in advanced stages of development, are likely to be candidates for Flight 2000. Therefore, it was assumed that acquisition of Flight 2000 avionics equipment will be through a commercial off-the-shelf (COTS) procurement.

Where development is required, the FAA's role will be to facilitate commercial development by providing effective guidance, clearly defined standards and streamlined certification methods.

A wide variety of aircraft will be equipped, ranging from single-engine GA aircraft to multi-engine air transports. The avionics will be utilized during the validation period, and it is assumed their residual to the Government will not justify their removal and therefore they will be left in place.

The schedule of activities that must be accomplished to install avionics suites into 2000 aircraft is shown by Figure 7.1.1 below. To achieve the Tier I date of September 30, 2000; tasks must be fully funded in FY1998.

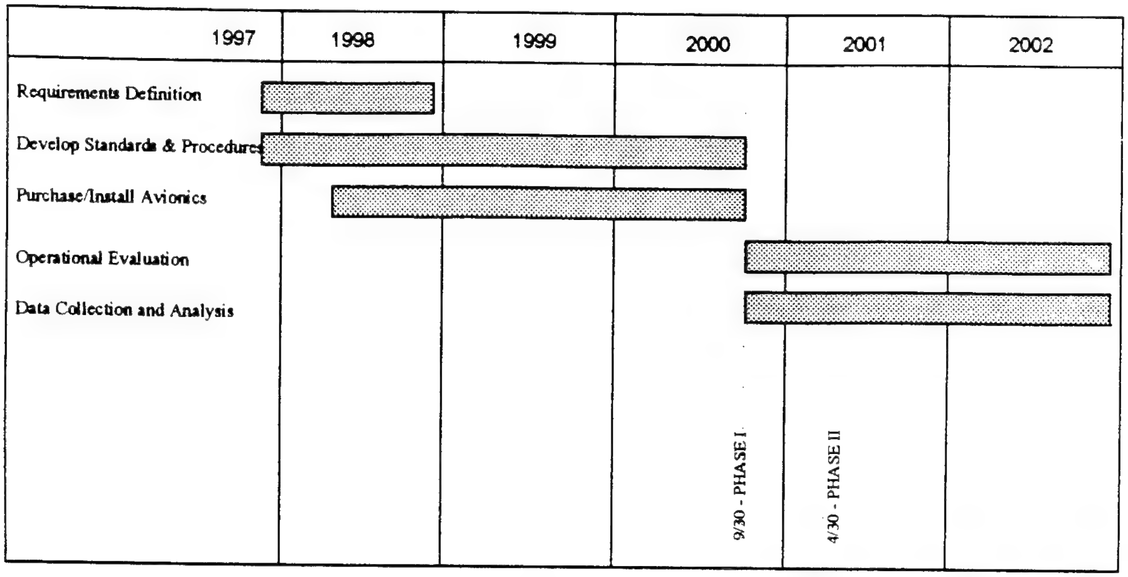


Figure 7.1.1
Avionics Schedule

Cost Summary

The avionics costs represented in this section are a summary of the cost elements developed by two Flight 2000 working teams, the Communications Component Team and the Cockpit Information Systems Team. Their cost estimates were as shown in Table 7.1.1 below.

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	TOTAL
Avionics Acquisition	**22,800**	**34,200**				**57,000**
Installation	**1,260**	**8,820**	**2,520**			**12,600**
Training		**1,140**	**4,560**			**5,700**
Documentation	**7,712**	**3,856**	**1,285**			**12,854**
Contractor Support	**12,312**	**6,156**	**2,052**			**20,520**
Testing	**1,348**	**4,717**	**674**			**6,739**
Flight Test	**790**	**5,925**	**1,185**			**7,900**
Avionics Inspection	**513**	**855**	**342**			**1,710**
Special Tools & Test Equipment	**755**	**955**				**1,710**
Regional Engineering Field Support	**330**	**4,293**	**1,981**			**6,604**
Deviation & Design Corrections		**771**	**331**			**1,102**
Government Salaries & Travel	**14,463**	**10,749**	**10,749**			**35,961**
TOTAL	**62,283**	**82,536**	**25,777**			**170,400**

Table 7.1.1 (in thousands)

7.2 Ground Systems Development

This category contains the schedule and cost estimates for developing the ground based systems/equipment required to accomplish the Flight 2000 Program objectives. The schedule and cost estimates start with the definition of requirements work effort and concludes with the system testing that will be accomplished prior to deploying the systems/equipment to the Alaska, Oakland and Hawaii sites. Both the schedule (Figure 7.2.1) and the cost estimate (Table 7.2.1) are listed in terms of the individual systems/equipments that must be either developed, or modified for the Flight 2000 Program.

Start dates for the requirements definition phase have been placed at October 1997 (beginning of FY1998), since this is the earliest time that funding for Flight 2000 is expected. If funding for Flight 2000 is received in FY1997, the overall Flight 2000 schedule can be accelerated over the dates presented in Figure 7.2.1.

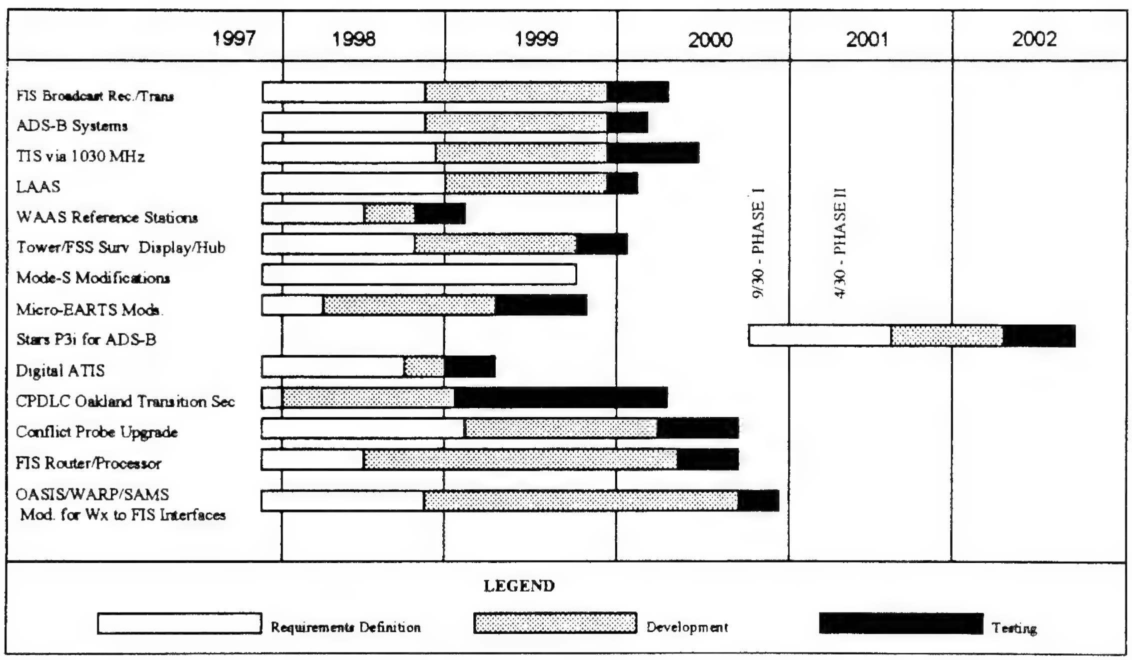


Figure 7.2.1
Ground Systems Development

The schedule for Tier III Activities is at Figure 7.2.2. These activities encompass the coordination tasks required by the FAA Integrated Product Teams (IPTs) and at the Tier III Activities sites. The schedule for this category represents only those IPT activities. Activities at the sites are captured in the respective site schedules.

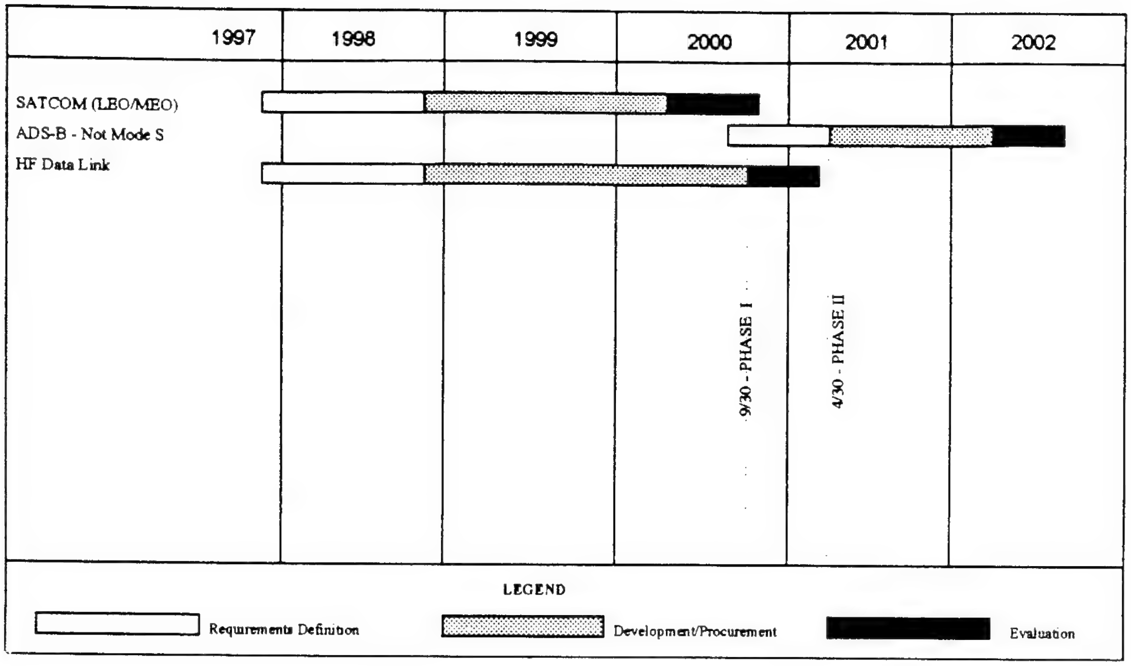


Figure 7.2.2
Tier III Activities

Table 7.2.1 shows the heaviest funding demands for Flight 2000 occurs in FY1998 and FY1999, with rapidly decreasing funding requirements for subsequent years. Having to implement a number of ground systems before September 30, 2000 requires this early major investment in systems development activities. The cost estimate for each system includes the tasks and expenditures required to bring a system from a prototype to a hardened system/equipment which successfully completes FAA operational testing. It does not include the unit cost of the system/equipment. The estimated unit cost of the system/equipment has been included with the individual site cost estimates contained in the Alaska, Oakland, and Hawaii Site categories. Cost estimates for Tier III include only those tasks being accomplished by the IPTs.

Flight 2000
Ground Systems Development - (Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
SATCOM A/G Comm (Testbed)	250	808	865	873	280	0	0	0	3,076
FIS Receiver Transmitter	2,400	1,265	265	273	0	0	0	0	4,203
ADS-B/Multilateration System	2,500	2,915	2,555	546	0	0	0	0	8,516
ADS-B Surveillance Server	6,500	3,315	1,465	273	0	0	0	0	11,553
TIS at 1030 MHz	2,700	1,365	1,215	273	0	0	0	0	5,553
Ground Station for ADS-B	850	750	500	0	0	0	0	0	2,100
Tower/FSS Surveillance Data Display and Hub	200	200	600	0	0	0	0	0	1,000
MODE S Modifications	400	308	266	0	0	0	0	0	973
LAAS	12,546	11,725	570	546	0	0	0	0	25,388
WAAS Reference Stations	3,308	565	550	273	0	0	0	0	4,696
ADS-B Other Than Mode-S (Testbed)	0	0	265	2,923	2,931	0	0	0	6,119
Micro EARTS Modifications for display of ADS-B Tracks	1,000	1,515	530	0	0	0	0	0	3,045
Micro EARTS Modification for Fusion Tracker	1,000	0	500	0	0	0	0	0	1,500
STARS P3I	0	0	530	6,386	2,022	0	0	0	8,938
Digital ATIS	200	100	0	0	0	0	0	0	300
HF Data Link	0	0	265	373	1,181	0	0	0	1,819
CPDLC to Oakland Transition Sectors (includes ATN)	7,560	6,455	3,748	1,282	281	0	0	0	19,327
Oceanic Conflict Probe Upgrade for ODAPS	4,500	7,515	3,130	546	0	0	0	0	15,692
FIS/Router Processor (Wx, SUA,NOTAMS, ASOS/AWOS Info)	1,940	1,505	860	0	0	0	0	0	4,305
OASIS Modification for FIS interfaces	1,750	1,258	1,565	0	0	0	0	0	4,573
WARP Modification for FIS interfaces	750	758	1,065	0	0	0	0	0	2,573
SAMS Modification for FIS interfaces	750	758	1,065	0	0	0	0	0	2,573
Included in the FY1998/FY1999/FY 2000 R,E&D budget request	-3,000	-8,000	-4,500	0	0	0	0	0	-15,500
Total Systems Cost	48,104	35,078	17,877	14,568	6,696	0	0	0	122,322

Table 7.2.2

7.3 Alaska Sites

Figure 7.3.1 is the schedule for installing and bringing into operational status the ground based systems necessary to provide Flight 2000 services to Alaska. Some of these services will be available at the Tier I date to include LAAS, WAAS, Digital ATIS, and the Mode S installed in Anchorage. Tier II (April 30, 2001) brings most of the remaining services to an operational status.

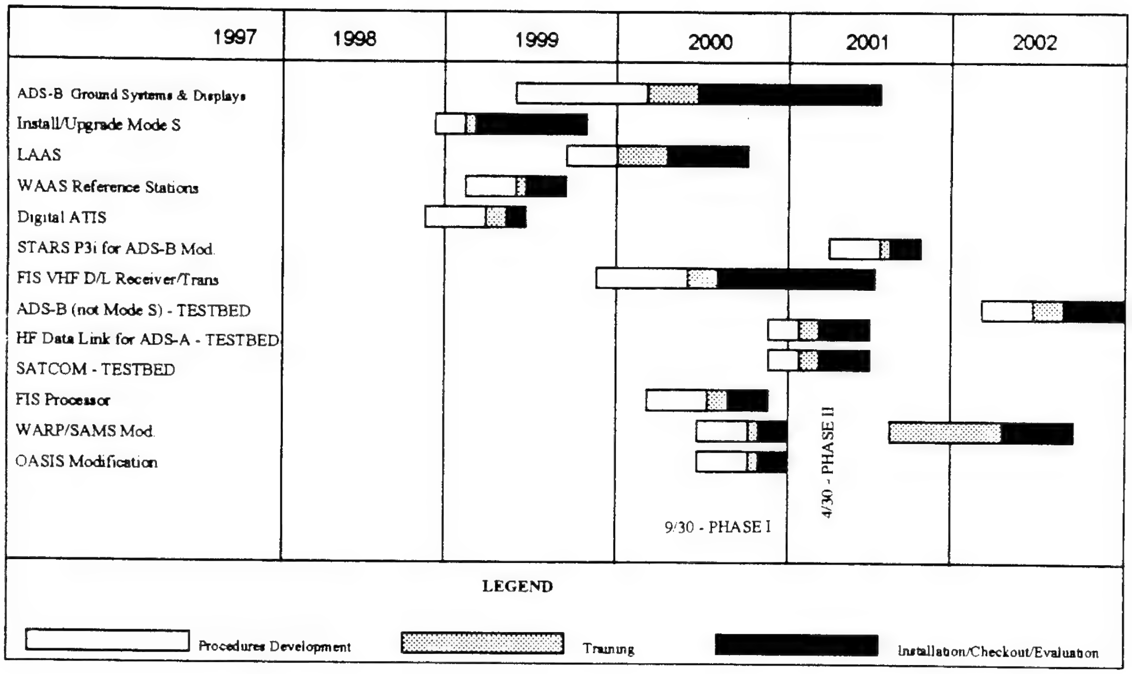


Figure 7.3.1
Alaska Ground Systems Deployment

Table 7.3.1 listed the costs in terms of the individual Alaska locations receiving the Flight 2000 ground systems/equipments. The cost estimates include the unit cost of each system/equipment being delivered to the site, site preparation costs, training costs for site personnel, installation costs, and testing and flight check costs for determining operational readiness. At the end of Table 7.3.1, is listed "Annual Operations Cost" which is the cost estimate for additional FAA personnel that will be needed to provide the Flight 2000 services utilizing the additional systems and equipments being placed at the Alaska sites. Expenses are estimated in FY1998, since the operational will need to be hired and trained prior to the new services becoming operational. The "Annual Maintenance Cost" entry is the estimated cost for contract maintenance support required for the new systems/equipment.

Flight 2000

Alaska Sites - (Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
Anchorage (Airport)	1,840	1,490	845	0	95	0	0	0	4,270
ASDE-3/AMASS Modification for ADS-B/Multilateration	0	790	250	0	0	0	0	0	1,040
Tower Surveillance Data Display	0	0	85	0	0	0	0	0	85
Install Mode-S	1,840	460	0	0	0	0	0	0	2,300
LAAS Site	0	0	460	0	0	0	0	0	460
STARS P3I ADS-B Modification Installed	0	0	0	0	95	0	0	0	95
Digital ATIS	0	170	0	0	0	0	0	0	170
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	70	50	0	0	0	0	0	120
Anchorage ARTCC	0	130	1,844	450	0	0	0	0	2,424
Ground Stations for ADS-B	0	0	230	0	0	0	0	0	230
Modified Micro EARTS System (ADS-B Targets, Fusion Tracker)	0	0	340	0	0	0	0	0	340
Tower Surveillance Display and Hub	0	0	85	0	0	0	0	0	85
ADS-B Surveillance Data Server	0	0	49	0	0	0	0	0	49
TIS via 1030MHz	0	0	100	0	0	0	0	0	100
HF Data Link (Test Bed)	0	50	420	0	0	0	0	0	470
Satellite A/G Comm.(Test Bed)	0	0	0	450	0	0	0	0	450
FIS Processor/Router	0	10	480	0	0	0	0	0	490
WARP Modification	0	0	45	0	0	0	0	0	45
SAMS Modification	0	0	45	0	0	0	0	0	45
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	70	50	0	0	0	0	0	120

Table 7.3.1 - Page 1 of 4

Flight 2000 - Alaska Sites
(Dollars in Thousands)

Juneau	0	0	1,165	0	0	0	0	0	1,165
Ground Stations for ADS-B	0	0	620	0	0	0	0	0	620
Tower Surveillance Display and Hub	0	0	85	0	0	0	0	0	85
LAAS Site	0	0	460	0	0	0	0	0	460
Bethel	0	0	1,839	0	0	0	0	0	1,040
Ground Stations for ADS-B/Multilateration System	0	0	1,040	0	0	0	0	0	1,040
Tower Surveillance Display and Hub	0	0	119	0	0	0	0	0	119
LAAS Site	0	0	460	0	0	0	0	0	460
TIS via 1030 MHz	0	0	100	0	0	0	0	0	100
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	0	120	0	0	0	0	0	120
Dillingham	0	0	120	305					425
Ground Stations for ADS-B	0	0	0	275	0	0	0	0	275
FSS Surveillance Display and Hub	0	0	0	30	0	0	0	0	30
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	0	120	0	0	0	0	0	120
Nome	0	0	0	425	0	0	0	0	425
Ground Stations for ADS-B	0	0	0	275	0	0	0	0	275
FSS Surveillance Display and Hub	0	0	0	30	0	0	0	0	30
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	0	0	120	0	0	0	0	120

Table 7.3.1 - Page 2 of 4

Flight 2000- Alaska Sites

(Dollars in Thousands)

Dutch Harbor	0	0	1,040	0	0	0	0	0	1,040
Ground Stations for ADS-B/Multilateration System	0	0	1,040	0	0	0	0	0	1,040
Kenai AFSS	0	25	120	325					470
OASIS Modification	0	25	0	0	0	0	0	0	25
SAT Comm (Test Bed)	0	0	0	325	0	0	0	0	325
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	0	120	0	0	0	0	0	120
Juneau AFSS	0	25	155	0	0	0	0	0	180
FSS Surveillance Display and Hub	0	0	35	0	0	0	0	0	35
OASIS Modification	0	25	0	0	0	0	0	0	25
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	0	120	0	0	0	0	0	120
COLD Bay AFSS	0	0	120	35	0	0	0	0	155
FSS Surveillance Display and Hub	0	0	0	35	0	0	0	0	35
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS)	0	0	120	0	0	0	0	0	120
Alaska (Other)									
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS) plus ADS-B capability (Gap Filler)	0	2,070	3,320	0	0	0	0	0	5,390
WAAS Reference Stations	0	1,560	0	0	0	0	0	0	1,560
GPS Approaches (49)	100	90	55						245
VFR/IFR RNAV routes (100)	350	400	150						900

Table 7.3.1 - Page 3 of 4

Flight 2000- Alaska Sites
(Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
Total Operations/Maintenance for Eval. (All Sites)	1,000	1,699	2,755	2,838	0	0	0	0	8,292
Total Site Cost	3,290	7,489	13,528	4,378	95	0	0	0	28,780
Post Eval. Operations & Maint.	0	0	0	0	2,923	3,010	3,101	3,194	12,228

Table 7.3.1 - Page 3 of 4

7.4 Hawaii Sites

Schedule and cost estimates were done for the Hawaii sites using the same estimating process as explained above for the Alaska sites.

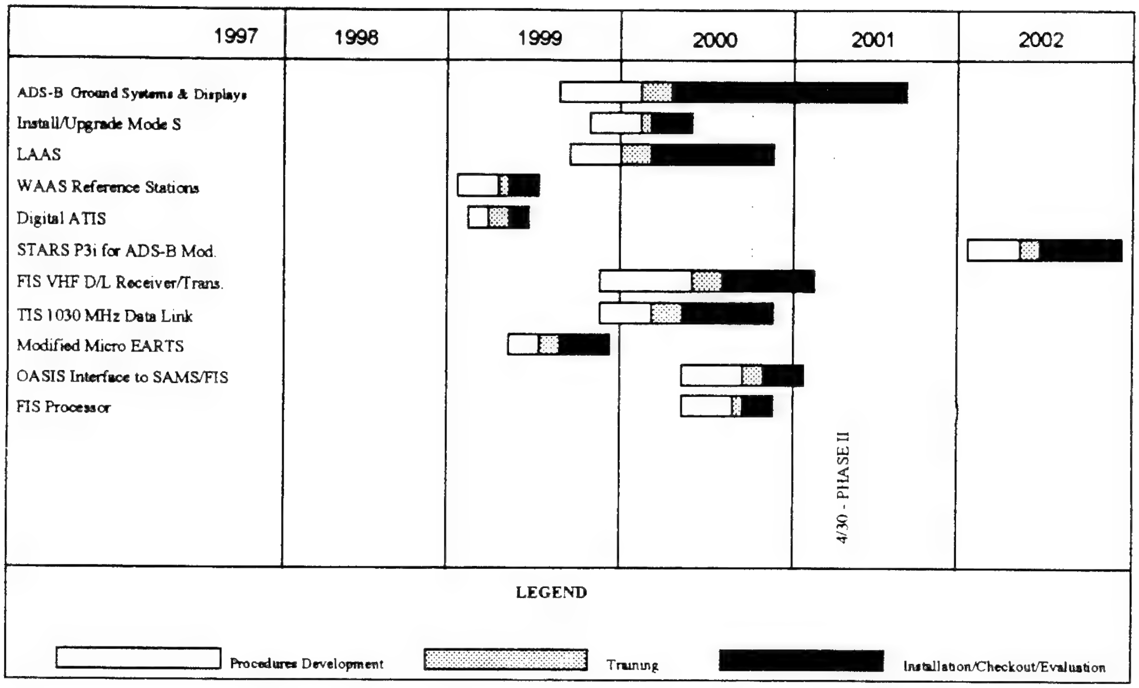


Figure 7.4.1
Hawaii Ground Systems Deployment

Flight 2000 - Hawaii Sites
(Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
Honolulu International Airport	100	1,210	540	0	0	0	0	0	1,850
Ground Stations for ADS-B & multilateration	0	740	300	0	0	0	0	0	1,040
STARS P3I ADS-B Modification Installed	0	0	95	0	0	0	0	0	95
LAAS Site	0	400	60	0	0	0	0	0	460
Tower Surveillance Display and Hub	0	0	75	0	0	0	0	0	75
Digital ATIS	100	70	0	0	0	0	0	0	170
HILO	70	600	405	0	0	0	0	0	1,075
Ground Station for ADS-B	0	140	135	0	0	0	0	0	275
STARS P3I ADS-B Modification Installed	0	0	95	0	0	0	0	0	95
LAAS Site	0	400	60	0	0	0	0	0	460
Tower Surveillance Display and Server	0	0	115	0	0	0	0	0	115
FIS VHF DL Receiver/Transmitter	70	60	0	0	0	0	0	0	130
Kona/Kailua	0	130	850	0	0	0	0	0	980
Ground Station for ADS-B	0	0	275	0	0	0	0	0	275
LAAS Site	0	0	460	0	0	0	0	0	460
Tower Surveillance Display and Server	0	0	115	0	0	0	0	0	115
FIS VHF DL Receiver/Transmitter	0	130	0	0	0	0	0	0	130

Table 7.4.1 - page 1 of 4

Flight 2000 - Hawaii Sites
(Dollars in Thousands)

Hoolehua	0	130	703	107	0	0	0	0	940
Ground Station for ADS-B	0	0	180	95	0	0	0	0	275
Tower Surveillance Display and Hub	0	0	63	12	0	0	0	0	75
FIS VHF DL Receiver/Transmitter	0	130	0	0	0	0	0	0	130
LAAS Site	0	0	460	0	0	0	0	0	460
Kahului	0	130	478	332	0	0	0	0	940
Ground Station for ADS-B	0	0	15	260	0	0	0	0	275
LAAS Site	0	0	460	0	0	0	0	0	460
Tower Surveillance Display and Hub	0	0	3	72	0	0	0	0	75
FIS VHF DL Receiver/Transmitter	0	130	0	0	0	0	0	0	130
Lihue	0	130	810	0	0	0	0	0	940
Ground Station for ADS-B	0	0	275	0	0	0	0	0	275
LAAS Site	0	0	460	0	0	0	0	0	460
Tower Surveillance Display and Hub	0	0	75	0	0	0	0	0	75
FIS VHF DL Receiver/Transmitter	0	130	0	0	0	0	0	0	130

Table 7.4.1 - page 2 of 4

Flight 2000 - Hawaii Sites
(Dollars in Thousands)

Honolulu CERAP	0	534	920	0	0	0	0	0	1,454
Ground Station for ADS-B	0	275	0	0	0	0	0	0	275
Tower Surveillance Display and Hub	0	75	0	0	0	0	0	0	75
ADS-B Surveillance Data and Server	0	44	0	0	0	0	0	0	44
TIS via 1030 MHz	0	0	100	0	0	0	0	0	100
FIS Processor	0	10	480	0	0	0	0	0	490
FIS VHF DL Receiver/Transmitter	0	130	0	0	0	0	0	0	130
Modified Micro-EARTS System (Display ADS-B Targets/Fusion Tracker	0	0	340	0	0	0	0	0	340
Honolulu Automated Flight Service Station	0	25	0	0	0	0	0	0	25
OASIS Interface to SAMS/FIS Processor	0	25	0	0	0	0	0	0	25
Mt. Halaekla	0	1,840	560	0	0	0	0	0	2,400
Install Mode S	0	1,840	460	0	0	0	0	0	2,300
TIS via 1030 MHz	0	0	100	0	0	0	0	0	100
Pahoa	0	1,840	560	0	0	0	0	0	2,400
Install Mode S	0	1,840	460	0	0	0	0	0	2,300
TIS via 1030 MHz	0	0	100	0	0	0	0	0	100

Table 7.4.1 - page 3 of 4

Flight 2000 - Hawaii Sites
(Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
Hawaii Other									
FIS VHF D/L Receiver/Transmitter (Wx, SUA, NOTAMS) plus ADS-B capability (Gap Filler)	0	1,000	1,205	0	0	0	0	0	2,205
WAAS Reference Stations	0	1,020	0	0	0	0	0	0	1,020
Total Operations/Maintenance for Eval. (All Sites)	400	1,951	2,576	2,714	0	0	0	0	7,641
Total Sites Cost	570	10,543	9,607	3,153	0	0	0	0	23,873
Post Eval. Operations & Maint.	0	0	0	0	2,795	2,879	2,853	2,795	11,322

Table 7.4.1 - page 4 of 4

7.5 Oakland ARTCC

The Oakland ARTCC designation includes system and equipment both to the domestic air traffic control portion of the facility and the oceanic control part of the facility. Oakland is also the site for a number of Tier III Activities. Figure 7.5.1 displays the schedule for the facility.

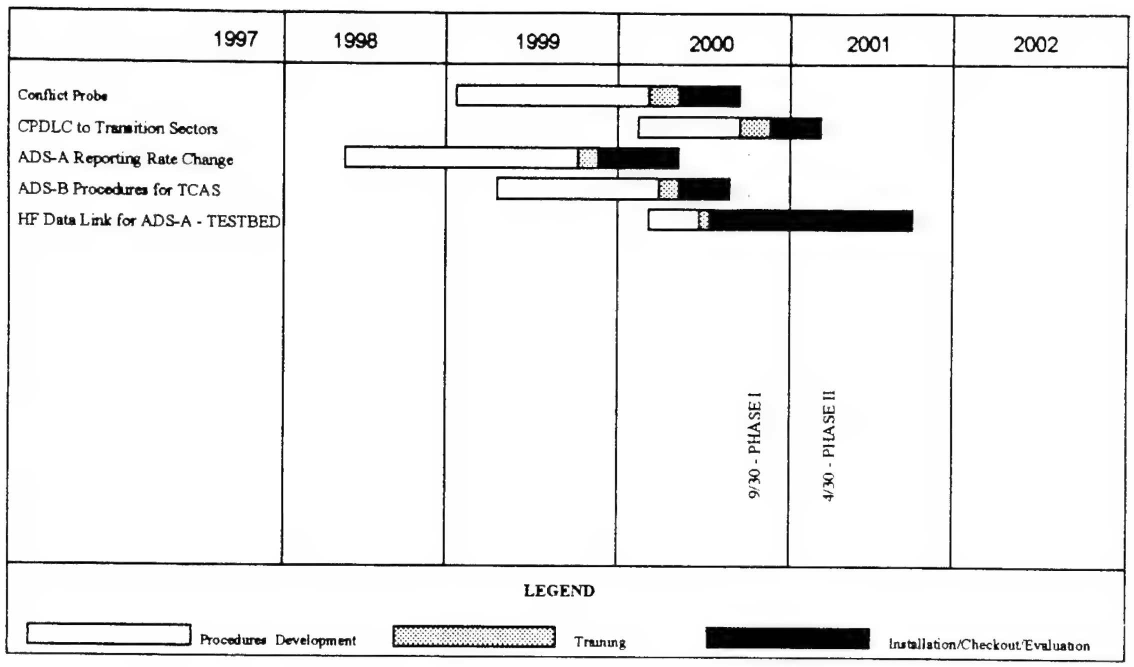


Figure 7.5.1
Oakland Ground Systems Deployment

Estimated costs for Flight 2000 activities at Oakland involve significant procedure development, software adaptation, and integration testing along with training. Table 7.5.1 displays these cost estimates.

Flight 2000 - Oakland ARTCC
(Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
Oakland									
Upgrade Conflict Probe	**30**	**550**	**420**	**0**	**0**	**0**	**0**	**0**	**1,000**
CPDLC to Transition Sectors (Incl. ATN Capability)	**60**	**1,040**	**1,200**	**0**	**0**	**0**	**0**	**0**	**2,300**
ADS-A Reporting Rate Change	**0**	**400**	**400**	**0**	**0**	**0**	**0**	**0**	**800**
ADS-B Procs. for TCAS in trail climb, crossings, flex tracks	**0**	**450**	**200**	**0**	**0**	**0**	**0**	**0**	**650**
HF Data Link for ADS-A (Oceanic Sectors) - TESTBED	**0**	**0**	**190**	**0**	**0**	**0**	**0**	**0**	**190**
Operations/Maintenance for Eval.	**0**	**306**	**907**	**965**	**0**	**0**	**0**	**0**	**2,178**
Total Site Cost	**90**	**2,746**	**3,317**	**965**	**0**	**0**	**0**	**0**	**7,118**
Post Eval. Ops. & Maint.	**0**	**0**	**0**	**0**	**994**	**1,023**	**1,054**	**1,087**	**4,158**

Table 7.5.1

7.6 Flight 2000 Program Engineering and Evaluation

This category captures the Flight 2000 program management and evaluation aspects of the program. Program management tasks continue through FY 2002 as shown by Figure 7.6.1, although at a reduced level, as can be seen by viewing Table 7.6.1. Included in this estimate is a Washington Program Office of eight persons and three coordination offices with a total of 5 FAA personnel.

This category also includes the simulation and modeling efforts, data collection concerning existing services and comparisons to performance data collected on the Flight 2000 services, human factors data collection and feedback into Flight 2000 procedures development.

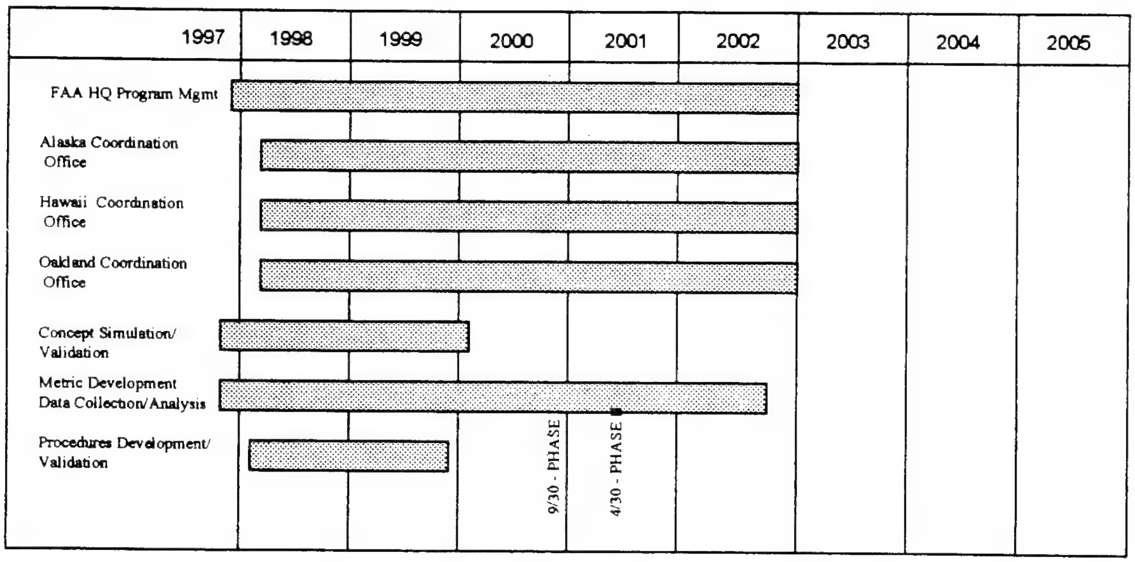


Figure 7.6.1
Program Engineering & Evaluation

Flight 2000
Program Engineering & Evaluation
(Dollars in Thousands)

	FY-1998	FY-1999	FY-2000	FY-2001	FY-2002	FY-2003	FY-2004	FY-2005	Total
Concept Validation and Evaluation Support	**14,380**	**14,050**	**8,150**	**2,430**	**2,000**	**0**	**0**	**0**	**41,010**
Ops Concept Simulation & Validation	4,000	4,000	4,000						
Metric Development and Performance Evaluation	3,000	1,900	1,150	1,100	1,100				
Procedures/Capabilities Development and Validation	7,380	8,150	3,000	1,330	900				
Program Management	**2,800**	**2,884**	**2,965**	**3,063**	**1,430**	**0**	**0**	**0**	**13,142**
Washington Program Office (8FTE's/2Contr.)	1,100	1,133	1,166	1,202	580				
Operations Center - Alaska (2FTE's/3Contr.)	650	670	690	710	350				
Operations Center - Hawaii (2FTE's/3Contr.)	650	670	690	710	350				
Operations Center - Oakland (1FTE/2Contr.)	400	412	420	440	150				1,822
Included in the FY1999/FY2000 R,E&D budget request	**0**	**-4,000**	**-4,000**	**0**	**0**	**0**	**0**	**0**	**-8,000**
TOTAL	**17,180**	**12,934**	**7,115**	**5,493**	**3,430**	**0**	**0**	**0**	**46,152**

Table 7.6.1

8.0 Issues, Next Steps, and Transition Strategy

8.1 Issues Requiring Resolution Early in the Flight 2000 Planning Process

The Flight 2000 architecture will lay the groundwork for NAS modernization, as well as support the key operational objectives of Flight 2000. In an attempt to demonstrate the operational improvements in the Flight 2000 timeframe some of the architecture decisions for Flight 2000 must be made in the near term. While many of these decisions will implement the systems needed for NAS modernization, others may not be end-state and will need to be evaluated one against another during the Flight 2000 demonstrations. As systems are developed and tested, NAS architecture decisions will be required before technologies are transitioned back to the contiguous 48 states.

The following items represent the major architecture issues that Flight 2000 will address.

1. ***What is the appropriate communications architecture needed to support the Flight 2000 NAS services?***

   To resolve this question Flight 2000 will explore various communications options. However, before national deployment of any communications solution, international standards and ICAO recommendations must be factored into the decision.

   For addressed data links (e.g., CPDLC, request/reply weather), the FAA plans to take advantage of both the user interest in, and industry plans to support VDL Mode 2. The FAA and users must determine that VDL Mode 2 is acceptable in areas of both performance and capacity and must support a transition to the CONUS. If VDL Mode 2 does not meet the performance or capacity requirements, other options for addressed data link services must be considered. Additionally, the Flight 2000 architecture is proposing to use VDL Mode 2 for broadcasting weather. Standards and international acceptance of VDL Mode 2 for broadcast services must be addressed.

   Where VDL Mode 2 is not available (mainly Oceanic), the FAA will use satellite links as well as HF data links. The FAA must address the performance and capacity of HF data link and its cost relative to existing and planned satellite data links.

   For navigation services the FAA plans to use GPS/WAAS/LAAS. These systems must demonstrate improved navigation services over existing installed systems at a reasonable cost. In addition, the FAA must evaluate the reliability and availability of these systems to determine to which existing navigational systems can be decommissioned.

   The communication architecture for ADS-B may prove to be one of the biggest challenges for the FAA and users in Flight 2000. Initially the FAA plans to use 1090 due to its maturity over other existing options. However, there are many pros and

cons surrounding this and other less mature ADS-B contenders. To help resolve this issue, the FAA has made a commitment to perform an even-handed evaluation of the major ADS-B candidates during the Flight 2000 demonstrations. The ADS-B architecture raises issues involving cost, performance, capacity, and spectrum availability.

2. ***What ground system automation improvements must be made to support the new Flight 2000 NAS services?***

Flight 2000 will implement new NAS services which must be integrated into existing ground systems. Key concerns include making the necessary modifications to existing ground systems in the Flight 2000 timeframe.

For tower systems Flight 2000 will add new displays to the tower cab that will provide a situation display for ADS-B equipped traffic. To support this new capability the FAA must address physical space limitations in today's tower cabs and the integration of these displays with existing tower automation systems. Also, the FAA must assess existing controller roles and responsibilities to determine how the new displays will be monitored and their effect on the current workload and operations.

Flight 2000 will not make any direct modifications to existing TRACON platforms. However, to support system transition of Flight 2000 capabilities, ADS-B surveillance data must be added to the STARS radar data processing as well as the STARS situation displays. The FAA's plan is to add this capability as part of a PrePlanned Product Improvement starting in 2001.

In Anchorage, CPDLC and ADS-B processing must be added to the ARTCC. The FAA plans to include CPDLC as part of the OCS-R program. Also, ADS-B processing must be added as an upgrade to Mirco-EARTS while the display of this data must be added to the DSR. Issues involved with these activities are largely centered on development risk and human factors issues with ADS-B displays on the DSR. At Oakland Center, CPDLC will be added to the en route Host Computer System. Issues involved with the architecture to support this capability via FANS1/A are mostly solved. However, future integration with ATN capabilities remains at issue. During transition to the CONUS, one of the biggest challenges will be to add these capabilities to the en route automation concurrent with Host replacement. However, DSR integration risks should be mitigated since DSR is included in the Flight 2000 demonstrations.

The FAA must address adding new weather services and SUA status to the NAS. Integration with existing weather and SUA products will be at issue. Additionally, system acquisition and ground system infrastructure issues must be addressed to support a national deployment of new Flight 2000 services.

3. ***What avionics improvements are required to support the new Flight 2000 services?***

New avionics will be developed to support the NAS services introduced in Flight 2000. New multi-mode, multi band radio technology is being proposed. This type of solution raises questions on technical feasibility of having one radio service multiple frequency bands. Additionally, cost factors for this new technology must also be examined as well as single point of failure issues associated with this approach.

Flight 2000 will introduce integrated cockpit displays to support multiple services. Human factors issues for shared displays and physical location of the equipment must be examined. Retrofit and certification of new systems in all classes of aircraft will pose a significant challenge. To support retrofitting these capabilities into existing avionics, cockpit architectures will need to be examined on a case by case basis.

Solutions for specific user needs must be developed. The FAA and user community must work together to develop these solutions and will be faced with the task of producing cost effective avionics packages for specific user needs. Packages of new capabilities must be tailored to specific user segments and low cost avionics solutions must be developed.

Issues Requiring Resolution Early in the Flight 2000 Planning Process

Flight 2000 and when the FAA several key integration and program related issues must be addressed. While the FAA recognizes that there are significant organizational and programmatic issues that are being worked as we prepare to implement Flight 2000, there are broad issues that need to be addressed to assure success in the program. Key issues include the following:

Avionics

<u>Legal and Tax Liability for Avionics</u>

Because of the unique nature of the Flight 2000 program and the nature of FAA's involvement the FAA there are liability concerns resulting from development, installation, improper use, and training.

It is unclear what the federal and state tax liabilities are to the recipient of the avionics. That tax liabilities are subject to the terms by which the avionics are provided. If provided as Government equipment for Government trials, the tax consequences are negligible, until such time as the FAA transfers (sells) ownership of the equipment to the user. Some users can depreciate the value, others cannot

<u>Avionics Integration</u>

The FAA is proposing a new set of avionics and functions for use in cockpits that are currently full of legacy equipment that is serviceable. The FAA needs to examine a

representative sample of existing aircraft avionics mixes and define how they will either be integrated or replaced. It is unclear how much existing equipment must be removed from some aircraft to accommodate new avionics provided through Flight 2000.

Avionics/Aircraft Certification Baseline

Achieving the advances aviation capabilities of Flight 2000, involves not only aircraft certification of avionics equipment and installation, but also operational certification of flight procedures and airmen. Integrating and expediting the certification of Flight 2000 systems to begin operations by September 2000 is a central challenge for the program. A related issue is how to reduce the cost of both initial certification and continued air worthiness of advanced technology flight systems to make their use more affordable and promote voluntary equipage.

Spectrum Risk

One objective of Flight 2000 is to be able to validate concepts such as ADS-B, flight information services, and other capabilities that are heavily dependent on communications. A significant issue for early modernization of the NAS is availability of spectrum. The available spectrum is limited by the need to continue to provide ground-based navigation through 2005 to 2010. Capabilities and procedures that require allocation of spectrum for FAA or commercial service provider use should be evaluated against the national availability and transition capabilities, not on the availability of spectrum in Alaska and Hawaii. Spectrum risk includes both the availability of channels and congestion.

Aircraft Down Time for Avionics

A significant issue for avionics installation is the amount of out-of-service time and possible loss of revenue that will be experienced during installation. The timing of avionics installation directly affects revenue return. The timing and amount of time required to install avionics needs to be defined by type of aircraft and operator, so that installation, inspection, and training can be synchronized with minimum economic disruption.

FAA Procedures

Procedural Change Test and Evaluation Planning

While procedures exist for developing GPS approaches and routes, that is not the case for anticipated uses of ADS-B and certain other data link functions. Procedures need to be developed, in collaboration with the user community, and test and evaluation criteria agreed upon. Safety assessments and monitoring must be conducted for most procedures. There will be a need for human-in-the-loop simulations and limited trials before implementing fully integrated testing of some capabilities (e.g., changes in separation

standards). Early design and consensus on these procedures is critical to success of Flight 2000.

Ground System Certification

Before air traffic control equipment is approved for use, it is certified. This certification process applies to most functions and services being evaluated in Flight 2000. In performing operational evaluations, air traffic controllers will be using Flight 2000 technologies to control aircraft. There needs to be an early understanding of what the requirements will be for certification of ground systems. Ground systems must be certified as part of an end to end system, with consistent level of validation of both airborne and ground elements.

Implementation of New Capabilities in a Mixed Fleet Environment

Aircraft that modernize may have increased operational advantages in terms of services and benefits, but the FAA's responsibility is to provide services to all users. Certain new procedures will be authorized based on aircraft equipage, while operating in a mixed-equipage environment. Procedural development must consider mixed fleet capabilities.

Each procedural evaluation must assure safety and deal with the mixed fleet environment in such a way as to provide benefit.

Unfunded Elements Relating to Flight 2000

RVSM Implementation in the Pacific

Flight 2000 assumes that RVSM is in place and will be investing in changing the oceanic conflict probe and dealing with new procedures yet to be developed with our Pacific partners on implementing RVSM. Implementation of RVSM is the Pacific is not presently funded. The details of the Pacific transition to RVSM are uncertain at this time.

Oakland Center Transitional Airspace Changes

Plans have been developed to transition oceanic transitional airspace from Los Angeles and Seattle Centers to Oakland Center. This change will improve transition to the oceanic routes, but requires some communications and surveillance changes that are currently unfunded.

Flight Data Processing for Hawaii Airspace

The relocation of the Honolulu CERAP does not include the move of the OFDP. It was originally planned to handle this capability out of Oakland Center. This has been determined to be unfeasible. Neither the move of the existing OFDP, or its replacement is currently funded.

ATN

Flight 2000 will initially operate with the existing FANS-1/a capabilities in oceanic airspace. During the operational phase, ATN is expected to become available and must provide at comparable interface with Flight 2000. Currently the NAS infrastructure improvements needed to support ATN are unfunded.

Other Issues

FAA Outreach Program for Users

Flight 2000 will require unprecedented user involvement. Early agreement on the scope, purpose, and structure of an outreach program is essential to planning how and when the FAA engages with the users, manufacturers, and affected personnel in Alaska, Hawaii, and Oakland Center.

8.2 Next Steps

With the publication of this initial plan for Flight 2000, only the first step is completed. The FAA plans to initiate immediately the following planning activities to provide additional detail in support of the Flight 2000 program plan:

- First, a transition strategy which addresses implementation in the remainder of the NAS will be developed. This will include appropriate engineering to assure that the automation systems such as the DSR and STARS can accommodate both data link and ADS-B as those capabilities are introduced into the rest of the NAS. In addition, integration of ADS-B information in decision support systems such as User Request Evaluation Tool (URET) and Center TRACON Automation System (CTAS) must be accomplished. Many of these activities will begin in parallel with Flight 2000 to assure the infrastructure will be available to accommodate the capabilities prior to 2005.

- A detailed plan for avionics certification, ground facilities, operational procedures and approval for use will be developed for Flight 2000. This plan will assure that certification for Flight 2000 becomes a prototype for the eventual upgrade of the total fleet and ground infrastructure that will occur to support modernization of the NAS.

- A detailed weather and flight information architecture will be developed to assure that a common set of flight information products are available both in the cockpit and the ATC and Flight Service Facilities. This architecture will support the data linking of information to the cockpit as well as accommodate limited down linking of airborne weather measurements.

- A detailed avionics acquisition strategy will be developed. This strategy will include the aircraft capabilities, installation, and necessary agreements with users as well as a detailed scheduled for implementation.

- A detailed plan for the acquisition, implementation, test and evaluation of the needed ground infrastructure components will be developed by each IPT. These plans will cover ADS-B, data link, and automation capabilities. For ADS-B, the plan will include a comprehensive and objective assessment of alternatives to the 1090 Mhz approach selected for Flight 2000. This assessment is needed prior to a final decision on an ADS-B implementation decision for the remainder of the NAS to ensure that emerging alternatives are considered fully.

- A detailed plan for the development of airborne and ATC and pilot issues will be developed. The plan will include a description of appropriate simulation and field assessment activities to assure that Flight 2000 capabilities have had extensive and thorough human factors assessment.

- An evaluation along with appropriate metrics to quantify improved operational capabilities must be developed. This plan must assure that both baseline and interim levels of improvements can be measured.

Each of these activities will be considered over the next several months, providing both the FAA and the user community with a clear road map of Flight 2000 activities and those associated activities to assure a successful transition to the rest of the NAS.

8.3 Transition Strategy

Flight 2000 will implement many new technologies that will impact communications, navigation, and surveillance systems both in the air and on the ground. In Flight 2000, systems will be deployed to verify operational feasibility and collect data on new capabilities. Once operational, evaluations are completed in Alaska and Hawaii, the FAA and users will be faced with the task of transitionising the successful new systems to the contiguous 48 United States. This task will involve the three major components of the Flight 2000 system; Ground Automation, Ground/Satellite Surveillance and Communications Systems, and Airborne Avionics Systems. This section provides some initial considerations for transition.

Ground Automation

Transition of Flight 2000 initiatives to ground automation systems will largely consist of ADS-B surveillance data to controller displays. New ADS-B reports must be fused with existing radar data being displayed in both the TRACON and en route systems. For the Tower, ADS-B data will require new displays and procedures. The engineering solution of using ADS-B data and presenting it to the controller will vary between ground systems. The concept of fusion of ADS-B data and radar data external to existing ground system automation will be explored as part of Flight 2000. However, this concept is still evolving

and other, nearer term solutions will be presented here as a potentially lower risk approaches.

Flight 2000 will also develop CPDLS services for the en route and oceanic domains. Transition of CPDLS controller I/O and procedures associated with its use are also addressed.

Other ground system automation that must be transitioned includes weather and SUA servers developed as part of Flight 2000. These systems will be developed to use standard sources of data during Flight 2000 and will be developed as stand-alone servers, thus the transition risks can be mitigated. What does need to be explored is the national deployment of these systems into the NAS.

Tower

New controller displays will be developed as part of Flight 2000 to provide a traffic situation display to tower controllers. This display will provide ADS-B surveillance data to the tower controller to allow better monitoring of aircraft and other vehicles on the airport surface. Transition of this system to the CONUS will be determined on the value added of this capability to the tower controller. If ground efficiencies are realized during Flight 2000 demonstrations then additional tower situation displays should be transitioned to domestic locations.

Issues involved with this system transition include:

1. Physical space limitations in today's overcrowded tower cabs
2. Additional controller personnel to monitor the new displays
3. Integration with existing tower displays/systems (e.g. D-Brite, PDC/ATIS)

Tracon

ADS-B Transition

The current ARTS platform will be discontinued in favor of the Standard TRACON ARTS Replacement System (STARS). Since the STARS will not be in place during the Flight 2000 demonstrations at the selected locations, there is little value in performing extensive TRACON ADS-B testing on old ARTS platforms. The strategy employed for ADS-B inclusion in STARS is to include modifications to STARS as part of a Pre-Planned Product Improvement (P^3I). The P^3I included as part of Flight 2000, will develop the necessary hardware interfaces, software processing, and controller interfaces to support ADS-B in the STARS.

The interfaces to STARS will be unique to that automation system. However, these interfaces should be industry standard since STARS is based on a COTS open system architecture. Processing within the STARS will be modified to accept and process ADS-

B data, but STARS will be designed, up-front, to make these modifications as simplistic as possible. Additionally, new controller interfaces will be required to display the ADS-B data. STARS requirements will be based on the lessons learned from the Alaskan and Hawaiian system implementation. In Alaska, the DSR will display the ADS-B data to the controller. The human factors rules and display techniques learned from this demonstration will be applied to the STARS displays to ensure a smooth transition from Alaska to the STARS platform.

En Route

ADS-B Transition

The ADS-B transition to en route will require ADS-B data be provided to the ground system automation and properly presented to the controller. Providing ADS-B data to the en route system might be done in different ways depending on the exact en route architecture at the time of transition. Both interfaces and processing must be considered. If Host replacement has taken place when transition begins, then the ADS-B interface must conform to the prescribed Host replacement interfaces. However, if Host is still in place at the time of transition, then ADS-B data might be fed to the Host via the PAMRI (similar to how radar data is interfaced today, see Figure 8.3-1) or the data might be sent to a processor on the HID/NAS LAN and enter the Host ia the HID, (radar data is interfaced today. See Figure 8.3.1 or the data might be sent to a processor on the HID/NAS LAN and enter the Host via the HID, (see Figure 8.3-2)

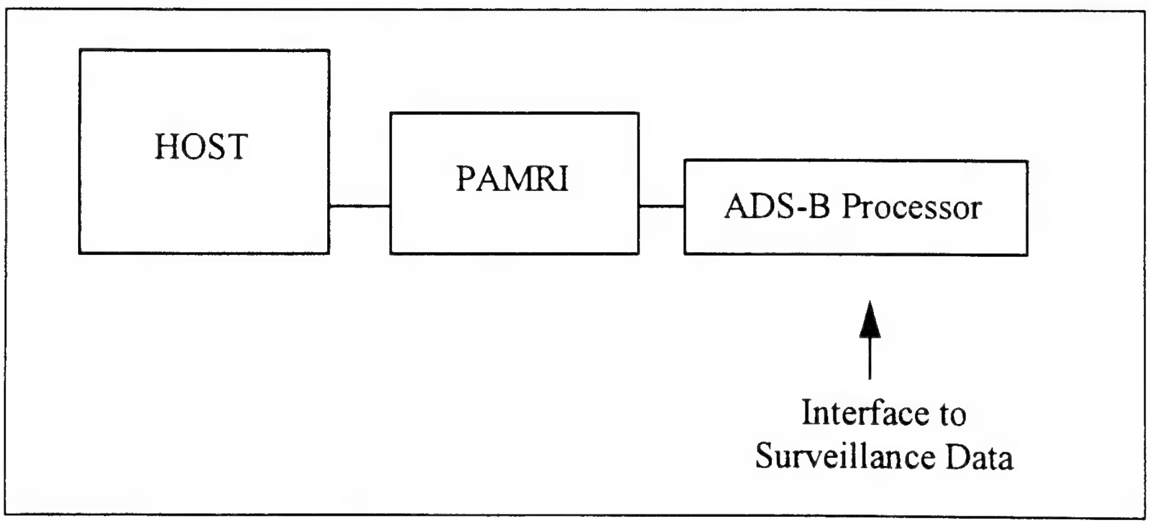


Figure 8.3-1
PAMRI ADS-B Interface

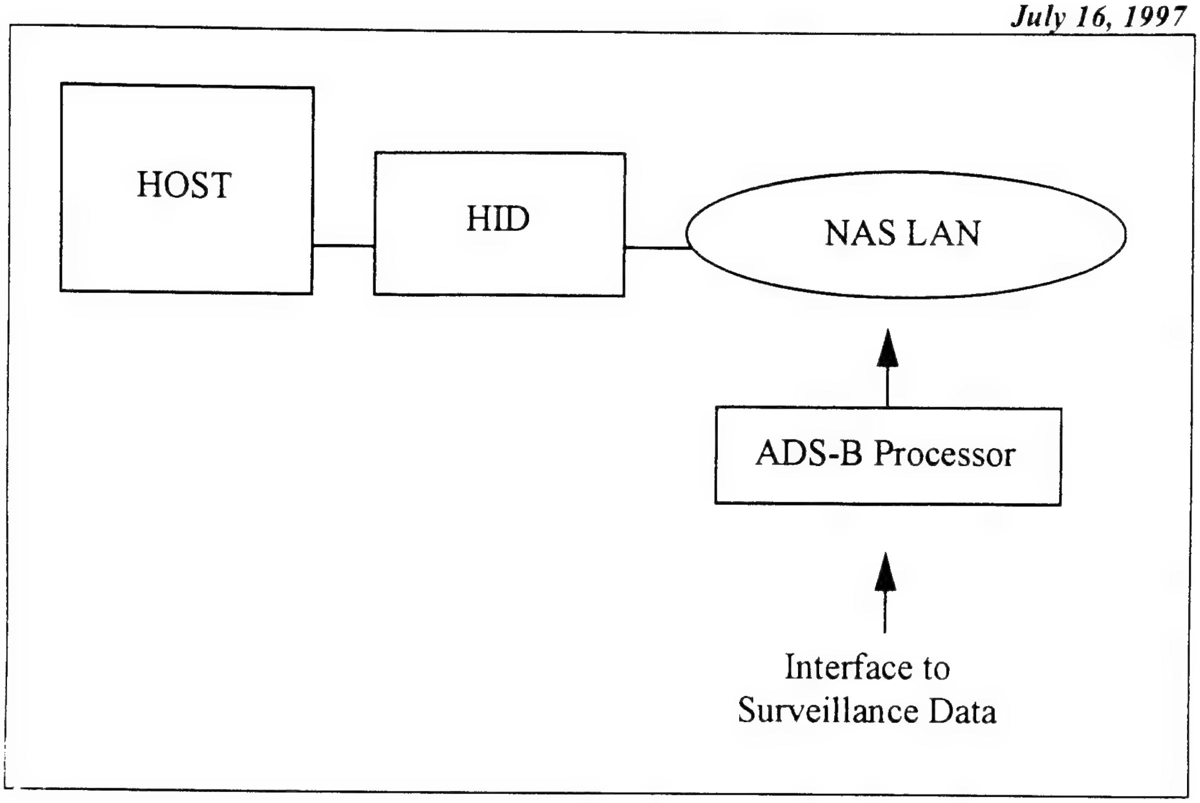


Figure 8.3-2
HID/NAS LAN ADS-B Interface

Once ADS-B data has been received by the Host, the data must be processed and displayed to the controller. The Host processing of radar data for the same target from different radars. A single radar is designated primary and the other radar as secondary. Normally, primary radar data is used to identify the target. If primary radar is not processed then a secondary source can be chosen by the automation. ADS-B data could be processed by the Host very similar to the logic applied to different radar sources to achieve the fusing process. New processing would be required within Host to receive and add the data to the current algorithms, however this is very feasible given the existing Host software architecture.

Once the data is processed by Host it must be displayed to the controller on the DSR. Since the DSR displays will be interfaced to the Micro-EARTS in Alaska, the display of ADS-B with radar data will be addressed by Flight 2000 while in Alaska. Therefore, transition of ADS-B data mixed with radar data on the DSR will be straight forward. Most, if not all, human factors concerns will be solved, and controller acceptance risks should be mitigated by Flight 2000.

CPDLC Transition

The Flight 2000 CPDLC demonstration will develop the components necessary to support CPDLC at the controller sector via FANS. The Flight 2000 demonstration will develop

all the necessary hardware/software for the Oakland en route HOST/DSR system. That includes the Host software and the Data Link Applications Processor (DLAP) residing on the NAS LAN. All necessary interfaces to the FAA's WAN (i.e. NADIN II) will be developed. The subnetworks (ACARS and VDL Mode 2) used in Flight 2000 will be interfaced to the Host/DLAP via NADIN II. Transition issues include:

1. Buy the hardware (i.e., DLAPs) at the additional 19 en route facilities. (This may not be necessary depending on the success of CPC)

2. Given that VDL Mode 2 meets capacity and performance requirements for CPDLC, deploy VDL Mode 2 nationally

3. If VDL Mode 2 does not meet the CPDLC performance requirements, VDL Mode 3 may be required to provide better performance for ATC messages.

Additonal transitions of CPDLC to all en route centers will largely be based on the user community's desire to transition to ATN. If ATN is selected, then additional software development will be required. However the bulk of Host software will remain intact from the Flight 2000 demonstrations. The majority of new development will focus on the addition of ATN protocols to the DLAP. Overall, this transition step, if required, will be orders of magnitude smaller since the Flight 2000 development will have overcome the major obstacles to CPDLC implementation.

Weather and SUA Systems

Ground system processors will be required to provide both weather and SUA information to aircraft. Much of this information can be made available via a request/reply mechanism over the VDL Mode 2 subnetwork. While other weather information will be broadcasted continuously. Flight 2000 will develop the ground based processors and interfaces necessary to collect and disseminate the weather products to the users. The ground based servers will be developed to interface to standard weather sources (e.g. NEXRAD) and thus be used anywhere these weather sources are available. Additionally, SUA status will be incorporated into these ground based processors with similar standardized interfaces.

Transition of these systems back to the lower 48 states should be very straight forward. With standardized interfaces to weather and SUA sources, and stand alone processors, these systems should move into the NAS with little problems. Consideration should be given to the links used and whether or not the will be adequate when moving to the CONUS. The capacity of VDL Mode 2 (with weather/SUA, CPDLC, AOC) must be investigated to determine if this is the best data link in the long term for these applications. Broadcast solutions and cost of the ground infrastructure should be weighted against potential benefits of the broadcast weather. Again, VDL Mode 2, as well as other potential links (depending on the ADS-B transition) should be investigated.

APPENDIX A - Acronym List

AAT	Air Traffic Service
A/C	Aircraft
ACARS	ARINC Communications Addressing and Reporting System
ACC	Area Control Center
ACD	Automated Conflict Detection
ACR	Avionics Computer Resource
ADIZ	Air Defense Identification Zone
ADNS	Aeronautical Data Network System
ADS-A	Automatic Dependent Surveillance - Addressed
ADS-B	Automatic Dependent Surveillance - Broadcast
ADTN	Administrative Data Transmission Network
AF	Airways Facilities
AFB	Air Force Base
AFSS	Automated Flight Service Station
AFTN	Aeronautical Fixed Telecommunications Network
AGL	Above Ground Level
AIM	Aeronautical Information Manual
ALS	Approach Lighting System
AMASS	Airport Movement Area Safety System
AMCP	Aeronaautical Mobile Communications Panel
AOPA	Aircraft Owners and Pilots Association
ANC	Anchorage
ANICS	Alaska NAS Interfacility Communications System
AOC	Airline Operations Center/ Aeronautical Operational Communications
APL	Airport Pseudolite
ARINC	Aeronautical Radio, Incorporated
ARS	Air Traffic Service Requirements Service
ARSR	Area Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASD	System Engineering and Architecture/Aircraft System Display
ASDE	Airport Surface Detection Equipment
ASOS	Automated Surface Observing System
ASR	Airport Surveillance Radar
ATA	Air Transport Association
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATCRBS	Air Traffic Control Radar Beacon System
ATCT	Air Traffic Control Tower
ATIS	Automated Terminal Information Sheet
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATNSI	Aeronautical Telecommunication Network System, Incorporated

ATS	Air Traffic Services
AWOS	Automated Weather Observing System
bps	bits per second
BPSK	Binary Phase Shift Keying
BUEC	Backup Emergency Communications
C/A	Coarse Acquisition
CAT	Category
CAT I	Category I approaches
CAT II	Category II approaches
CAT III	Category III approaches
CD	Common Digitizer
CDC	Computer Display Channel
CDM	Collaborative Decision Making
CDMA	Code Division Multiple Access
CDR	Continuous Data Recording
CDTI	Cockpit Display of Traffic Information
CEP	Central East Pacific
CERAP	Center/Radar Approach Control
CHI	Computer Human Interface
CIP	Capital Investment Program
CIS	Cockpit Information System
CNS	Communications, Navigation, Surveillance
Com/Comm	Communications
CONOPS	Concept of Operations
CONUS	Continental United States
COTS	Commercial Off The Shelf
CPDLC	Controller to Pilot Data Link Communications
CPS	Central Processor Subsystem
CRDA	Cooperative Research and Development Agreement
CSMA	Carrier Sense Multiple Access
CTAS	Center TRACON Automation System
DA	Descent Advisor
D-ATIS	Digital Automatic Terminal Information Service
DB	Database
DBRITE	Digital Bright Radar Indicator Tower Equipment
DDL	Digital Data Link
DGPS	Differential GPS
DL	Datalink
DLAP	Datlink Applications Processor
DME	Distance Measuring Equipment
DMN	Data Multiplexing Network
D-NOTAMS	Digital NOTAMS

DoD	Department of Defense
DO	Document (RTCA)
DOP	Dilution of Precision
DOT	Department of Transportation
DOTS	Dynamic Ocean Tracking System
D8PSK	Differential 8-level Phase Shift Keying
DSB-AM	Dual Side Band - Amplitude Modulation
DSR	Display System Replacement
DSS	Decision Support System
DTR	Dynamic Track Rerouting
D-TWIPS	Digital TWIPS
DUATS	Direct User Access Terminal System
EARTS	Enroute Automated Radar Tracking System
EDCM	Enhanced Collaborative Decision Making
ELT	Emergency Locator Transmitters
E-PIREP	Electronic Pilot Report
ETMS	Enhanced Traffic Management System
F&E	Facilities and Equipment
FAA	Federal Aviation Administration
FAATC	William J. Hughes FAA Technical Center
FANS	Future Air Navigation System
FAST	Final Approach Spacing Tool
FDIO	Flight Data Input/Output Device
FDP	Flight Data Processor
FDMA	Frequency Division Multiple Access
FID	Flight Information Display
FIR	Flight Information Region
FIS-B	Flight Information Services Broadcast
FL	Flight/Flight Level
FMS	Flight Management System
FPS	Military Flight Positioning Radar
FSS	Flight Service Station
GA	General Aviation
GANS	Global Access, Navigation and Safety Program
GATM	Global Air Traffic Management
GDP	Ground Delay Program
GEO	Geostationary Earth Orbit
GFE	Government Furnished Equipment
GLONASS	Global Navigation Satellite System (Russian Federation)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRL	Gateway Reservation List

GUS	Geostationary earth orbit Uplink Station
GWS	Graphical Weather Services
HARS-R	High Altitude Route System - Replacement
HCS	HOST Computer System
HF	High Frequency
HID	Host Interface Device
HNL	Honolulu
HUD	Heads Up Display
ICAO	International Civil Aviation Organization
ID	Identification
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
Info	Information
INS	Inertial Navigation System
IOC	Initial Operational Capability
IPT	Integrated Product Team
IRU	Inertial Reference Unit
ITWS	Integrated Terminal Weather System
JPALS	Joint Precision Approach and Landing System
JUN	Juneau
KHz	KiloHertz
Km	Kilometers
LAAS	Local Area Augmentation System
LAN	Local Area Network
LDRCL	Low Density Radio Control Link
LEO	Low Earth Orbit
LINCS	Leased Interfacility NAS Communications System
LRR	Long Range Radar
m	meters
MAC	Media Access Control
MAMS	Military Airspace Management System
MASPS	Minimum Aviation System Performance Standard
MDA	Minimum Descent Altitude
MEA	Minimum Enroute Altitude
MEO	Medium Earth Orbit
METAR	International Meteorological Aviation Report Format
MHz	MegaHertz
MIT/LL	Massachusetts Institute of Technology/Lincoln Laboratory

MLS	Microwave Landing System
MOCA	Minimum Obstruction Clearance Altitude
MOPS	Minimum Operational Performance Standards
MSK	Minimum Shift Keying
MSL	Mean Sea Level
MWP	Meteorological Weather Processor
NADIN	National Airspace Data Interchange Network
NAILS	National Airspace Integrated Logistics Support
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
Nav	Navigation
NAVAID	Navigation Aid
NCAR	National Center for Atmospheric Research
NDB	Non-directional Beacon
NEXCOM	Next Generation Air/Ground Communications System
NEXRAD	Next Generation Radar
NIMS	NAS Infrastructure Management System
NM	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NOCC	National Operational Control Center
NOPAC	North Pacific Composite Route System
NOTAM	Notice to Airmen
NRP	National Route Program
NWS	National Weather Service
O&M	Operations and Maintenance
OASIS	Operational and Supportability Implementation System
OCS	Offshore Computer System
ODAPS	Oceanic Display and Planning System
OFDPS	Offshore Flight Data Processing System
OPS	Operational Processor System
ORD	Operational Readiness Demonstration
P^3I	Preplanned Product Improvement
PC	Personal Computer
P-Code	Precision Code
PDC	Pre-departure Clearance
pFAST	Passive Final Approach Spacing Tool
PIREP	Pilot Report
PPS	Precise Positioning Service
PSR	Primary Surveillance Radar
Pstn	Position

R&D	Research and Development
RAPCON	Military Radar Approach Control
RCAG	Remote Communications Air/Ground
RCO	Remote Communication Outlet
RDLP	Radar Data Link Application Processor
RF	Radio Frequency
RIS	Radar Interface Subsystem
RISC	Reduced Instruction Set Computer
RMS	Root Mean Square
RNAV	Area Navigation
ROM	Rough Order of Magnitude
R/T	Receiver/Transmitter
RTR	Remote Transmitter/Receiver
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima
SAMS	Special Use Airspace Management System
SAR	Search and Rescue
SARPS	Standard and Recommended Practices
SATCOM	Satellite Communications
SCAT-1	Special Category I
SDN	Surveillance Data Network
sec	seconds
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Advisory
SMA	Surface Movement Advisor
SMC	System Monitor Console
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
STARS	Standard Terminal Automation Replacement System
STDMA	Self-organizing Time Division Multiple Access
SUA	Special Use Airspace
SUR	Surveillance
TACAN	Tactical Air Navigation
TAF	International Terminal Area Forecast Format
TCAS	Traffic Alert and Collision Avoidance System
TCS	Terrestrial Communications System
TDLS	Tower Data Link System
TDMA	Time Division Multiple Access
TDWR	Terminal Doppler Weather Radar
Terr	Terrain
TFM	Traffic Flow Management
TIS	Traffic Information Service

TMA	Traffic Management Advisor
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control
TSO	Technical Service Order
TWIP	Terminal Weather Information for Pilots
UHF	Ultra High Frequency
URET	User Request Evaluation Tool
VDL	VHF Data Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omni-directional Range
VOR/DME	VOR collocated with DME
VORTAC	VOR collocated with TACAN
WAAS	Wide Area Augmentation System
WARP	Weather and Radar Processor
WGS-84	World Geodetic Survey-1984
WMS	Wide Area Master Station
WRS	Wide Area Reference Station
WSR	Weather Surveillance Radar
WX	Weather
ZAN	Anchorage ARTCC
ZFW	Fort Worth ARTCC
ZHN	Honolulu ARTCC
ZID	Indianapolis ARTCC
ZME	Memphis ARTCC
ZOA	Oakland ARTCC

APPENDIX B - Operational Improvements Mapped to Free Flight Recommendations

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
1. RNAV Procedures	RNAV procedures for a minimum of 49 airport in Alaska and each airport in Hawaii
2. Quickly develop standards, criteria, procedures, and training for use of area navigation capabilities	RNAV VFR and IFR routes, FMS approaches in Alaska and Hawaii
3. RNAV routes below FL 180	Providing an off-airway capability that provides terrain clearance through a combination of GPS and a terrain data base, eliminating the need for Victor Airway structure
4. Expand National Route Program	Not in Flight 2000
5. Decrease the 200 nm radius restricition for NRP filing	Increased use of RNAV arrival and departure paths to join free flight airspace
6. Develop mechanisms to provide pre-departure feedback to flight planners	Not in Flight 2000 This represents an element of CDM linking FAA with the AOCs
7. Implement rationing-by-schedule during Ground Delay Programs	Not in Flight 2000
8. Establish more flexible ground delay program	Not in Flight 2000
9. Establish coordinated effort to define	Complete prior to Flight 2000
information on special use airspace (SUA)	
10. Improve information exchange on SUA status	SUA status will be uplinked directly to aircraft in Alaska and Hawaii
11. Develop and implement real time SUA notification	Will bee a service in Flight 2000
12. Streamline the FAA certification process	Major thrust of Flight 2000 is the streamlining of avionics certification
13a. In collaboration with the users, the FAA should make a decision on the initial air/ground data link for domestic ATC	Develops and deploys flight information services, evaluates ADS-B, provides for FANS CPDLC transition from the oceanic to domestic en route airspace
13b. The FAA should collaborate with users in the continuing development of oceanic data link	HF data link, the use of SATCOM, and expanding the functionality of FANS-1 equipage is planned for the airspace controlled by Alaska and Oakland
14. Improve telecommunications to enhance flow of information for traffic flow management	Not part of Flight 2000

APPENDIX B - Operational Improvements Mapped to Free Flight Recommendations (cont.)

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
15. Incorporate airline schedule updates in FAA decision support systems	Not part of Flight 2000
16. Enhance or replace the current ATM monitor alert function	Not part of Flight 2000
17. Expedite deployment of D-ATIS and PDC	D-ATIS to be added as part of FIS functionality in Anchorage and Honolulu
18. Initiate standards for cockpit display of traffic information	CDTI is part of the core set of avionics for evaluation
19. Deploy a ground-based conflict probe	Replacing oceanic conflict probe but domestic en route probe is not part of Flight 2000
20a. Expedite technologies for improved transition to and from terminal airspace	Flight 2000 does not negatively impact CTAS deployment
20b. Move mature elements of CTAS forward into implementation	
21. Investigate feasibility of using WAAS for vertical guidance in RVSM	Not part of Flight 2000
22. The FAA should support down-link of real-time aircraft-reported weather	As part of avionics Upgrade 1, aircraft may provide electronic PIREPs with temperature, humidity, and winds for use in icing predictions
23. Develop more accurate forecasts of convective activity	Not part of Flight 2000
B. Work with the user community to achieve consensus and timing for ADS-B technology	Major emphasis area of Flight 2000, including certification for separation of aircraft and evaluation for other procedural changes enabled by improved surveillance
24. Develop methodology and tools to measure and predict dynamic density	Not part of Flight 2000
25. Collaborative exchange of planning information	FAA to AOC collaboration not part of Flight 2000; however, up-link of NOTAMs, SUA status, and weather via data link are part of collaboration with the cockpit
25a. FAA and users must determine the details of improved user-TFM interaction	Not part of Flight 2000
25b. Develop programs and flexible procedures to exchange real-time information with shift toward controlled time of arrival	Not part of Flight 2000

APPENDIX B - Operational Improvements Mapped to Free Flight Recommendations (cont.)

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
26. Establish procedures for aircraft-to-aircraft separation.	Uses CDTI and evaluation of ADS-B with specific experiments supporting self-separation capabilities.
27. Implement precision missed approaches and precision simultaneous approaches and departures.	Flight 2000 will use precision missed approaches and departures with additional testing on applicability of ADS-B for independent arrival streams to closely spaced runways (testing at an existing PRM location following full human-in -the-loop simulation).
28. Investigate increasing runway acceptance by permitting two aircraft to occupy the runway at the same time.	Not part of Flight 2000
29. Expand NRP below FL 290.	Not part of Flight 2000
Figure 3. Issued Advance Notice of Proposed Rulemaking to implement domestic RVSM above FL290	Not part of Flight 2000
31. Determine requirements for reduced horizontal separation standards, including surveillance performance	Performance of ADS-B will be measured, both air-to-air and air-to-ground and applied to horizontal separation as appropriate
32. Rulemaking to remove the 250 knot restriction below 10,000 feet	Not part of Flight 2000
33. Determine human perception of separation time and distance buffers	Performance of ADS-B will affect potential changes in separation and both pilot and controller acceptance of surveillance information will be evaluated
34. Human-in-the-loop simulations of dynamic resectorization	Not part of Flight 2000
35. Reemphasize the role of the Airport Improvement Program in increasing airport capacity	Not part of Flight 2000
MTI. Increase FAA ARTCC decision support capabilities to include the total US navigation data base	Not part of Flight 2000
MT2. Accelerate and expand programs to support GPS/WaaS as a primary navigation system	Develops procedures and provides avionics that promote transition to satellite-based navigation
MT3. Ensure that STARS and DSR have the "hooks" to accommodate ADS-B	Develops surveillance server, displays ADS-B on DSR

APPENDIX B - Operational Improvements Mapped to Free Flight Recommendations (cont.)

Free Flight Task Force Recommendation	Flight 2000 Enabling Capability
MT4. Develop and implement weather and flight information into the cockpit	Provides an opening day weather, NOTAMs, SUA status via data link to aircraft equipped with the core system plus Upgrade 1
MT5. Develop and deploy dynamic sectorization	Not part of Flight 2000
MT6. Develop and deploy ADS in non radar areas to support user-preferred trajectories	Flight 2000 relies on ADS-A in the oceanic domain and ADS-B in domestic arispace to improve surveillance in non radar areas, including the potential use of air-to-air applications of ADS-B to achieve user-preferred trajectories
FT1. Expand the number of airports to receive surface surveillance capability	Adds ADS-B at 11 airports after demonstration at Anchorage and Bethel
FT2. Define surveillance architecture and infrastructure for both terminal and en route airspace incorporating both dependent and independent surveillance elements	Performance and integration of ADS-B into the NAS is a critical element of Flight 2000 and will lead to refinement of the surveillance architecture for the NAS
FT3. Determine LAAS capability and implement LAAS	Flight 2000 will install LAAS at Anchorage, Juneau, and Honolulu as operational systems and may require additional units supporting other airports

APPENDIX C - Capabilities of Current and Flight 2000 Activities

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added by Flight 2000
2.0 PREFLIGHT PLANNING		
2.1 Greater exchange of information to provide better descriptive and predictive capabilities for users and service providers	• Initial Collaborative Decision Making (ASD to Industry, data exchange for GDP, schedule compression, HARS-R ration by schedule • Expanded Collaborative Decision Making (ECDM) (flight substitution/control by time of arrival, flow management DSS enhancements, etc.) • Collaborative System Planning (NAS Status Info., Collaborative Rerouting, Performance Assessment, etc.)	• See Operational Improvement 2.2 below

2.2 Improved weather access	• Automated Weather Observing System (AWOS) deployment complete including sensors to detect freezing rain and precipitation
	• Weather And Radar Processor (WARP) deployment complete including NEWRAD interface and common weather situational awareness within the en route environment
	• Integrated Terminal Weather System (ITWS) deployment underway including weather downlinked from aircraft, very accurate near-term forecasts, and interfaces to NEXRAD, low-level windshear alert systems, microburst predictions, storm cell, lightning information, winds aloft, runway winds, etc.
		• Distribution of weather products to flight service stations
		• Improved access to information in the cockpit:
		  • Via voice from flight service station, via data link (in line of sight) in text and/or graphical form
		  • Parity of weather information for pilots and controllers
		• Improved weather information for flight planning, especially low-altitude icing reports from E-PIREPS
		  • Use of Alaska Internet site for weather distribution to uses for flight planning

2.3 Better and more rapid access to Special Use Airspace (SUA) information, a) not in A/C, b) in A/C		• Interface to SAMS/MAMS for FSS's • Data link of SUA information in cockpit

APPENDIX C - Capabilities of Current and Flight 2000 Activities (cont.)

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added By Flight 2000
2.0 PREFLIGHT PLANNING		
2.0 improved coordination among TFM, ATC, and users	• OASIS deployment complete providing improved data dissemination for flight planning, flight advisory services, and search and rescue	• Data link of NOTAMS and SUA through use of FIS Processor • Use of ADS-B by FSSs as traffic advisory • Internet access of flight service data in Alaska
Operational Improvement	**Capabilities Available Independent of Flight 2000**	**Capabilities Added by Flight 2000**
3.0 AIRPORT SURFACE		
3.1 Reduced communication and coordination activities through the expansion of data link capabilities to more airports	• Data link for Digital-Automatic Terminal Information Service (D-ATIS) and Pre-Departure Clearance (PDC) deployed	• Reduced communication congestion via D-ATIS but PDC not available due to lack of Host and interface
3.2 More efficient ground operations through improved planning of surface movements, runway assignments, sequencing to departure thresholds, and sequencing aircraft into flows aloft	• Surface Movement Advisor (SMA)	• Aircraft with identification displayed in tower for ADS-B equipped aircraft
3.3 Improved safety through more accurate and reliable surface detection capabilities and display of surface traffic in the tower and in the aircraft		• Improved surface situational awareness in tower and cockpit via ADS-B, multilateration, ASDE-3/AMASS (ANC only), and LAAS for precision where necessary
3.4 Improved pilot situational awareness		• Cockpit display of surface situational information, including surface surveillance via ADS-B and multilateration
3.5 Reduced taxi delays—data link delivery of taxi clearance	• Deployment of PDC at additional locations in CONUS	
3.6 Reduced taxi delays in low visibility operations	• Airport Configuration via ECDM	• Improved surface situational awareness in tower and cockpit via ADS-B, multilateration, ASDE-3/AMASS (ANC only), and LAAS for precision where necessary
3.7 Real-time airport weather and status via data link	• AWOS deployment complete • WARP deployment complete • ITWS deployment underway	• Same as Operational Improvement 2.2

APPENDIX C - Capabilities of Current and Flight 2000 Activities (cont.)

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added By Flight 2000
4.0 DEPARTURE AND ARRIVAL		
4.1 Enhanced decision support system to assist service providers in maintaining separation runways, and sequencing aircraft	• Advanced Conflict Detection being deployed • Standard Automation Radar System (STARS) with pre-planned improvements continue to be deployed for Data Link, CTAS, and precision runway monitor, traffic management interfaces, etc.	• More accurate surveillance information for Conflict Alert and MSAW (via ADS-B) • AMASS interface
4.2 Navigation aids that allow RNAV-based and satellite-based departure and arrival routes, as well as precision approaches	• WAAS is fully operational • LAAS in early stages of deployment • Approach procedures developed for existing precision runways	• RNAV VFR/IFR routes • GPS precision and non precision approaches • Terrain Data Base • Differential correction (LAAS)
4.3 Procedural changes to allow departing aircraft to have speeds greater than 250 kt at altitudes below 10,000 ft in class B airspace	• 250 kt restriction lifted for most aircraft	
4.4 Improved terminal area weather information and cockpit displays	• AWOS deployment complete • ITWS deployment underway	• Same as Operational Improvement 2.2
4.5 Increased pilot situational awareness; decreaesed visual approach minima		• RNAV VFR/IFR routes • GPS precision and non precision approaches • Cockpit display of traffic, terrain, weather information
4.6 Increased ability to accommodate user—preferred arrival/departure routes, climb/descent profiles, runway assignments	• Descent Advisor to assist in providing fuel optimal descent approaches	• RNAV VFR/IFR routes • GPS precision and non precision approaches • Navigation and obstruction information for pilot • More effective communication with data link • Use of ADS-B, including multilateration, for expanded surveillance coverage
4.7 Better coordination among facilities, and among TFM, ATC, and users	• AOCNET and link to FAA to increase information sharing and potential for collaborative decision making	

APPENDIX C - Capabilities of Current and Flight 2000 Activities (cont.)

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added By Flight 2000
4.0 DEPARTURE AND ARRIVAL		
4.8 Improved safety and runway utilization		• RNAV VFR/IFR routes • GPS precision and non precision approaches • Terrain Data Base • ADS-B • Differential correction (LAAS) where precision required
4.9 Increased surveillance coverage		• Use of ADS-B, including multilateration, for surveillance • Surveillance, server, integrating ADS-B into u-EARTS • ADS-B air-to-air

APPENDIX C - Capabilities of Current and Flight 2000 Activities (cont.)

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added by Flight 2000
5.0 EN ROUTE/CRUISE		
5.1 Reduction in en route delays	• FDIO replacements continue • Host/DARC replacement deployment underway	• RNAV VFR/IFR routes • Terrain Data Base • Expanded surveillance coverge via ADS-B • Use of ADS-A for en route airspace in Alaska • Air-to-air testing to support self-separation
5.2 Increased ability to accommodate user preferred trajectories, schedule, and flight sequence through improved controller efficiency and reduced separation	• Descent Advisor • Automatic Conflict Detection • WARP deployment complete • Traffic Management Advisor (TMA) to optimize arrival of traffic into areas of constrained traffic	• Controller Pilot Data Link Capability (CPDLC) • Expanded surveillance coverage via ADS-B and use ADS-A in ocean to assist in user preferred maneuvering
5.3 Improved airspace safety through increased air-ground surveillance coverage and air-air surveillance coverage		• Use of ADS-A and ADS-B for separation with ADS-B used as coverage gap filler and for air-to-air maneuvering
5.4 Enhanced hazardous weather avoidance	• Initial severe weather avoidance tool as part of ECDM • WARP deployment complete	• Same as Operational Improvement 2.2
5.5 Increased pilot situation awareness		• ADS-B with cockpit display of traffic information and traffic information service
5.6 Improved coordination among TFM, ATC, and users	• Automatic Conflict Detection	• Data link of SUA information in cockpit • Controller Pilot Data Link Capability (CPDLC)
5.7 Reductions in ground delays		
5.8 Support to transition airspace sequencing and spacing: provides higher runway utilization and increased airport capacity	• Descent Advisor • Automatic Conflict Detection • Traffic Management Advisor	
5.9 Increased use of low altitude direct routes using GPS navigation		• RNAV VFR/IFR routes • GPS precision and non precision approaches • Terrain/obstruction Data Base • Expanded surveillance coverage via ADS-B

APPENDIX C - Capabilities of Current and Flight 2000 Activities (cont.)

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added By Flight 2000
5.0 EN ROUTE/CRUISE		
5.10 Increased airspace capacity through reduced vertical separation minima		• Reduced vertical separation is not part of Flight 2000 but where ADS-B serves as radar coverage gap filler separation will be improved • Experiments in use of ADS-B and ADS-A with oceanic RVSM can lead to possible vertical separation improvement
5.11 Enhanced search and rescue operations		• Expanded surveillance coverage and enhanced situational awareness via ADS-B • Improved weather and terrain avoidance • Testing of air/ground satellite communications • Last reported position with improved precision • Ability for other airborne aircraft to see disabled aircraft • Faster rescue response

APPENDIX C - Capabilities of Current and Flight 2000 Activities (cont.)

Operational Improvement	Capabilities Available Independent of Flight 2000	Capabilities Added By Flight 2000
6.0 OCEANIC		
6.1 Increased airspace capacity through reduced separation minima	• Reduced Vertical Separation Minima	• Surveillance coverge via ADS-A
6.2 Dynamic rerouting, step, climb, achieve optimum altitude, cruise climb, fuel and time savings		• Enhanced oceanic probe • Surveillance coverage via ADS-A during maneuvering • TCAS Change 7 (ADS-B) allowing climb, passing and descend maneuvers at greater range than possible with TCAS alone
6.3 Dynamic management of route structures, more opportunity to obtain flexible tracks and user preferred profiles	• Initial and enhanced CDM	• Enhanced oceanic probe • Surveillance coverage via ADS-A during maneuvering • TCAS Change 7 (ADS-B) allowing climb, passing and descend maneuvers at greater range than possible with TCAS alone